State of Connecticut.

PUBLIC DOCUMENT No. 34.

EIGHTEENTH ANNUAL REPORT

OF THE

STORRS

AGRICULTURAL EXPERIMENT STATION,

STORRS, CONN.

FOR THE YEAR ENDING JUNE 30, 1906.

PRINTED BY ORDER OF THE LEGISLATURE

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1907

PUBLICATION

APPROVED BY

THE BOARD OF CONTROL.

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Publications of the Station

AVAILABLE FOR FREE DISTRIBUTION.

The following publications of the Storrs Agricultural Experiment Station are available for distribution, and, as long as the supply lasts, will be sent free to all who desire them.

BULLETINS.

No. 7. Chemistry and Economy of Food.
No. 12. The Ripening of Cream by Artificial Bacteria Cultures.
No. 14. The Elm Leaf Beetle.
No. 20. A Study of Dairy Cows.
No. 21. The Ripening of Cream.
No. 23. The Relation of Bovine Tuberculosis to that of Man and its Significance in the Dairy Herd.
No. 25. The Covered Pail a Factor in Sanitary Milk Production.
No. 26. The Relation of Temperature to the Keeping Property of Milk.
No. 27. Poultry as Food.
No. 28. Dairy Observations.
No. 29. Records of a Dairy Herd for Five Years.
No. 30. Spraying Notes for 1903.
No. 31. Food Value of a Pound of Milk Solids.
No. 32. Protecting Cows from Flies.
No. 33. A Successful Brooder House.
No. 34. Discussion of the Amount of Protein Required in the Ration for Dairy Cows.
No. 35. The Camembert Type of Soft Cheese in the United States.
No. 36. Poultry Suggestions for the Amateur.
No. 37. The So-called "Germicidal Property" of Milk.
No. 38. The Marketing of Poultry Products.
No. 39. Pig Feeding Experiments.
No. 40. Creamery Problems.
No. 41. Spraying Notes, 1904–1905.
No. 42. Quality of Milk Affected by Common Dairy Practices.

REPORTS.

The Reports of the Storrs Agricultural Experiment Station for 1889, '90, '94, (Part III.) '95, (Part III.) '96, (Part II.) '98, '99, 1900, 1901, 1902–3, 1904, 1905, 1906, are available for free distribution.

Address all requests to the Director of Storrs Agricultural Experiment Station, Storrs, Conn.

Report of the Treasurer

For the Fiscal Year Ending June 30th, 1906.

The following summary of receipts and expenditures, made out in accordance with the form recommended by the United States Department of Agriculture, includes, first, the Government appropriation of $7,500, and, secondly, the Government appropriation of $2,500 and the annual appropriation of $1,800 made by the State of Connecticut, together with various supplemental receipts. These accounts have been duly audited according to law, as is shown by the Auditor's certificates, copies of which are appended.

GOVERNMENT APPROPRIATION—RECEIPTS AND EXPENDITURES

RECEIPTS

United States Treasury,	$7,500 00

EXPENDITURES

Salaries,	$3,545 81
Labor,	1,451 74
Publications,	56 50
Postage and stationery,	183 54
Freight and express,	75 72
Heat, light, water, and power,	116 63
Chemical supplies,	402 62
Seeds, plants, and sundry supplies,	477 17
Feeding stuffs,	230 50
Library,	68 50
Tools, implements, and machinery,	94 14
Furniture and fixtures,	88 80
Scientific apparatus,	94 70
Live stock,	166 55
Traveling expenses,	223 98
Contingent expenses,	15 00
Buildings and repairs,	208 10
	$7,500 00

AUDITOR'S CERTIFICATE

I, the undersigned, duly appointed Auditor of the Corporation, do hereby certify that I have examined the books and accounts of the Storrs Agricultural Experiment Station for the fiscal year ending June 30, 1906, that I have found the same well kept and classified as above, and that the receipts for the year from the Treasurer of the United States are shown to have been $7,500 and the corresponding disbursements $7,500, for all of which proper vouchers are on file and have been examined by me and found correct, thus leaving no balance.

And I further certify that the expenditures have been solely for the purposes set forth in the act of Congress approved March 2, 1887.

(Signed) L. J. Storrs, *Auditor*.

Storrs, Conn., July 15, 1906.

ADAMS APPROPRIATION—RECEIPTS AND EXPENDITURES.

RECEIPTS

United States Treasury,	$2,500 00

EXPENDITURES

Salaries,	$616 66
Labor,	186 31
Postage and stationery,	57 30
Freight and express,	12 69
Chemical supplies,	484 94
Seeds, plants, and sundry supplies,	299 19
Feeding stuffs,	65
Library,	67 00
Tools, implements, and machinery,	127 68
Scientific apparatus,	417 11
Live stock,	30 42
Traveling expenses,	78 35
Buildings and repairs,	121 70
	$2,500 00

AUDITOR'S CERTIFICATE

I, the undersigned, duly appointed Auditor of the corporation, do hereby certify that I have examined the books and accounts of the Storrs Agricultural Experiment Station for the fiscal year ending June 30, 1906, that I have found the same well kept and classified as above, and that the receipts for the year from the Treasurer of the United States are shown to have been $2,500, and the corresponding disbursements $2,500, for all of which proper vouchers are on file and have been examined by me and found correct, thus leaving no balance.

And I further certify that the expenditures have been solely for the purposes set forth in the act of Congress, approved March 16, 1906.

(Signed) L. J. STORRS, *Auditor.*

STORRS, CONN., July 15, 1906.

STATE APPROPRIATION AND SUPPLEMENTAL RECEIPTS

RECEIPTS AND EXPENDITURES

RECEIPTS

State of Connecticut,	$1,800 00
Miscellaneous receipts,	1,481 33
	$3,281 33

EXPENDITURES

Salaries,	$433 32
Labor,	309 94
Postage and stationery,	5 52
Freight and express,	3 50
Chemical supplies,	83 77
Seeds, plants, and sundry supplies,	75 95
Library,	5 29
Tools, implements and machinery,	55 00
Live Stock,	13 20
Traveling expenses,	55 56
Contingent expenses,	119 95
Buildings and repairs,	448 06
Balance,	1,672 27
	$3,281 33

AUDITOR'S CERTIFICATE

I, the undersigned, duly appointed Auditor of the Corporation, do hereby certify that I have examined the books and accounts of the Storrs Agricultural Experiment Station for the fiscal year ending June 30, 1906, that I have found the same well kept and classified as above, and that the receipts for the year from the State of Connecticut are shown to have been $1,800, and the receipts from miscellaneous sources $1,481.33, making the total receipts from the State and miscellaneous sources $3,281.33. The corresponding disbursements were $1,609.06, for all of which proper vouchers are on file and have been by me examined and found to be correct, thus leaving a balance of $1,672.27.

(Signed) L. J. STORRS, *Auditor.*

STORRS, CONN., July 15, 1906.

D. W. PATTEN, *Treasurer.*

Report of the Director.

Friends of agricultural education will note with pleasure the passage by Congress of the "Adams Act" increasing the appropriation of the federal government to agricultural experiment stations. This act provides that for the year ending June 30, 1906, there shall be appropriated to each state five thousand dollars ($5,000) and that this appropriation be increased each year by two thousand dollars ($2,000) until the amount finally appropriated to each state shall be fifteen thousand dollars ($15,000) in addition to the appropriation already made to each state under what is known as the "Hatch Act" of 1887. Owing to the fact that there are two experiment stations in Connecticut, the amount derived by this station from the federal government has been but one-half of the annual appropriation to this state. The receipts of the station, then, for the past year have been the regular Hatch fund of $7,500, the state appropriation of $1,800, and the Adams fund of $2,500. This increase in our appropriation will be especially appreciated by those who are familiar with the work of the station, as it will enable us to equip the various departments more completely and to pay a larger portion of the salary of the men engaged in both college and station work. Heretofore the salaries have been largely paid from the college funds, even though the men engaged devoted a considerable part of their time to experiment station work. The matter of salaries has now been adjusted until it is probable that the men receive from the station all the salary which should properly be charged to the station funds.

MORE STATE AID NEEDED.

By special provision of the Adams act no portion of the fund derived from that source can be used for printing or for attending farmers' institutes, or for disseminating agricultural information; but the fund must be entirely devoted to original,

scientific, research work. But a limited amount of the federal funds can be devoted to the maintenance of buildings and for repairs. It is expected by the federal government that the state will furnish the necessary buildings in which the experiment work is to be conducted. At the present time our state appropriation is but $1,800 per year. This is but little more than sufficient to provide for the equipment of laboratories, for heat, light, and water supply, and for meeting the various other expenses which cannot properly be charged to the federal funds. Were the state appropriation larger it would enable the experiment station to conduct coöperative experiments in various sections of the state, and these experiments would serve to popularize the work of the station and to advance the cause of agricultural education throughout the state. We have frequent calls from the farmers of the state for information and for assistance in some line of work, and to properly respond to these calls oftentimes requires a personal visit from some member of the station staff. This expense should all be borne by the state, leaving our federal funds entirely for original research work.

CHANGES IN THE STAFF.

During the past year Mr. E. R. Bennett, assistant horticulturist, resigned to accept a similar position at the Colorado Experiment Station. This position was filled by the appointment of Mr. C. D. Jarvis, a graduate of Ontario Agricultural College, Guelph, Ont., and post-graduate student in horticulture at the Cornell University. Dr. B. B. Turner, chemist of the station, was granted a two years' leave of absence, and the position of chemist was filled by the appointment of Mr. H. D. Edmond, a graduate of this college, and for the past year assistant in chemistry in both college and station. Dr. H. W. Conn, who for many years has been supervisor of work in dairy bacteriology, severed his connection with the station.

COÖPERATION WITH THE UNITED STATES DEPARTMENT OF AGRICULTURE.

The cheese investigations in connection with the Dairy Division, Bureau of Animal Industry, United States Department of Agriculture, have progressed favorably during the

past year. The making of Camembert cheese has been perfected until now the product is uniform, and we have been able to render valuable assistance to various factories in the United States who are attempting to make this type of cheese. The work of instruction in cheese making will, without doubt, occupy a portion of the time of our workers in the future. While some progress has been made in experiments with Roquefort cheese, we have not yet been successful in perfecting this work. There is every indication, however, that as a result of our experiments we will ultimately be as successful with the Roquefort type as we have been with the Camembert type. This coöperative work with the Dairy Division has been carried forward in every way perfectly satisfactory to the Storrs Experiment Station.

While this cheese making work is not at the present time of direct, practical importance in Connecticut, yet there is no reason why there could not be established in this state factories for the making of some of these types of European cheese, and it is our hope that as a result of this work there may arise a new industry in the state. The larger part of the direct cash outlay connected with this work is borne by the Department of Agriculture, the experiment station furnishing apparatus, laboratories, milk to work with, and giving direct supervision to the experiment work.

DAIRY INVESTIGATIONS.

The records of dairy cows have been kept during the past year as heretofore, and the representative dairy herd of the college makes a valuable equipment for experiment work.

The Burrell-Lawrence-Kennedy milking machine has been under test since October 1, 1905. This machine has been tested not only to determine if it would milk cows satisfactorily, but determinations have been made for the bacterial content in the milk when drawn by these machines, of the effect of these machines upon the cow, and when the experiments are concluded we will know the result of the use of this machine upon the total milk yield for the year as well as upon the quality of the milk and economy in milking. A bulletin will be published later giving the detailed results of the work with the milking machine.

The work of the dairy department of this station is generally recognized as being of a high order, and as the dairy industry is probably our most important agricultural industry in the state, it seems proper that in our work we should recognize the importance of this line of investigation.

DAIRY BACTERIOLOGY.

There is no article of food which is more readily contaminated than milk. It furnishes ideal conditions for the development of bacteria, and city health officers have come to realize that pure milk can be secured only from careful dairy methods. Many of our cities are adopting regulations which require that milk containing bacteria in excessive quantities shall be rejected. In our work in dairy bacteriology we are endeavoring to determine the sources of contamination of milk and the types of bacteria which enter the milk from these various sources. Not all bacteria are harmful; some are actually beneficial; but up to the present time there have been no sources of information which would enable the inspector to reject milk containing the harmful bacteria and accept the beneficial, providing the milk contained only the beneficial bacteria. In our laboratory studies are being made and a classification of dairy bacteria has been prepared which will prove of immense value to students in dairy bacteriology. This classification of dairy bacteria is published as a part of this report and also as a separate article for students' use.

POULTRY INVESTIGATIONS.

The most important problem before the poultryman to-day is how to secure vitality in young chicks. This problem is being investigated by our poultry department. A bulletin has been prepared entitled "Poultry Observations" and in this bulletin will be given results of investigations with reference to the death of young chicks.

HORTICULTURAL INVESTIGATIONS.

The work in horticulture was seriously handicapped during the past year by the resignation of Mr. Bennett. It was so late in the season when Mr. Jarvis began his work with us that not much could be accomplished in the way of research.

Several lines of investigation are, however, under way and we have hopes that our work in horticulture will in time be recognized as ranking with the work done in dairying and in poultry husbandry.

FIELD EXPERIMENTS.

The station is seriously handicapped in conducting field experiments from the fact that no land is owned by the college which is well adapted to field experiment work. Our fields are for the most part hilly and the soil is entirely lacking in uniformity. Field experiment work does not mix well with the regular farm work. Inasmuch as the college farm is limited in area and the fields which can be tilled are still further limited in area, we have not at the present time any land suitable for experiment work. Some means should be taken to secure for the experiment station some land adapted to experiment work.

LECTURES AT FARMERS' INSTITUTES AND OTHER MEETINGS.

The demand upon various members of the station staff for addresses at farmers' institutes, and for various meetings throughout this and other states has become so great as to at times seriously interfere with station duties. While a certain amount of this work is valuable and keeps the men in touch with the farming interests of the state, yet when these demands become so great that the men are called from their duties for several days during the week and for several weeks in succession the matter becomes so serious that it should receive attention. If every call for institute work must be met and these calls are as frequent as they have been during the past year, then it will be necessary to secure for the various departments able assistants who can carry on the work of the experiment station so that the work will not be interfered with. It may frequently happen that absence from duties for a single day may result in sacrificing the work which has been conducted through the entire year. The details of experiment work must be looked after every day if the experiment is to amount to anything. These details cannot properly be looked after except by some one who is in close touch with the work.

In conclusion I wish to express my appreciation of the conscientious work done by all the members of the staff. I wish to thank the Board of Trustees for the interest they have taken in the experiment station, and President Stimson for the cooperation which he has given at all times in matters relating to station work.

L. A. CLINTON.

Report of the Dairy Husbandman.

To the Director of the Storrs Agricultural Experiment Station:

SIR:—The department of dairy husbandry for the college was created in 1901. Two years later a similar position was formed in the experiment station and the position filled by detailing the college dairyman to devote a part of his time to experimental work. In this dual alliance the station assumed only a meagre part ($100 per year) of the salary of the dairyman, and could exact only a corresponding part of his time. About five hundred dollars per year of station funds were allowed for experimental work. This arrangement has continued up to the present time, July 1, 1906.

The Board of Control has realized, however, that the importance of the dairy industry in Connecticut warranted the expenditure of a larger portion of the station funds in the investigation and solution of dairy problems. It is gratifying to report that beginning with July 1, a large amount of money will be set aside for investigation in dairying. The station also has assumed the responsibility for the payment of one-half the salary of the dairyman.

This recognition and provision for the experimental dairy work will be appreciated by all the dairymen of the state. The future outlook for this department is exceedingly bright. The writer is of the opinion that additional lines of work should not necessarily be taken up, but that the increased funds should be used in strengthening what is already under way. The feeding experiments especially should be conducted for *longer* periods in the future than in the past. More results, therefore, may not be looked for in the future than in the past because of additional funds, but more thorough and painstaking work may be expected.

Respectfully submitted,

CHARLES L. BEACH.

Report of the Bacteriologist.

To the Director of the Storrs Agricultural Experiment Station:

SIR:—The work of the department of dairy bacteriology for the year ending June 30, 1906, has included studies in a number of lines of work. Several lines of investigation which were begun in previous years have been continued during the year. These include subjects which require a considerable length of time in order to arrive at results sufficiently accurate to warrant a report. Some of this work is still incomplete, and will be continued during the coming year. Some of the work has been sufficiently completed to warrant a report, which will be found in this volume.

During the summer of 1905, the writer was asked by the Dairy Department at Washington to make some bacteriological studies of a milking machine which was about to be placed upon the market. Some valuable results were obtained which will soon be published by the Dairy Division at Washington. The time given to this work, however, was not sufficient to make a complete study of the bacteriological problems connected with the use of the machine, but the results were sufficient to indicate their economic value in milk production. It was considered desirable for the station to continue this line of work, and in October arrangements were made between this station and the makers of this milking machine to install a plant at the college dairy barn. Since October careful studies have been made with these machines. The work has been divided into two parts; that part relating to yield and chemical composition of the milk being under the direction of Prof. C. L. Beach, while the sanitary and bacteriological problems have been under my own direction. A report of these experiments will be published in the near future.

The bacteriological work upon Camembert cheese has also been continued throughout the year. An extended series of

experiments has been carried on for the purpose of determining the part which bacteria play in the flavor production in this type of cheese. Very satisfactory results have been obtained, and this work will be reported by C. J. Mason.

The studies of market milk which have been carried on during the past two or three years have been continued throughout the year. While this work is not yet complete, part of it will be reported upon soon. The sanitary condition of market milk is receiving so much attention at the present time that it seems wise to continue the studies already under way regarding the conditions of production and the sanitary qualities of the milk which is being placed upon the market throughout the state. For this reason considerable time has been put upon this line of work. In view of the steadily increasing demand for a cleaner milk supply, it is highly essential that the producers know the necessary conditions for the production of such milk.

In order to get more definite knowledge regarding the sources of bacteriological contamination, and the most economical means for preventing the same, this department has made a series of studies for the purpose of determining the effect upon the germ content of the milk of some of the common stable practices. One report on this work has already been made in a recent bulletin of this station, and further reports will be made later.

Respectfully submitted,

W. A. Stocking, Jr.

Report of the Poultryman.

To the Director of the Storrs Agricultural Experiment Station:

SIR:—During the past year the squab industry has had special attention. A large amount of data has been gathered which will probably be ready for publication in a few months.

Experiments have also been tried as to the use of snow in the place of water for poultry during the winter, and the results were found to be very satisfactory. This experiment will be repeated this coming winter.

The hopper method of feeding is still being tested. Where the birds had free range it has been found very satisfactory, but with limited range it has not been as successful except with a few varieties of fowls. This method is now in use for feeding dry mashes, and with some flocks the entire ration is fed from hoppers.

The causes for the great mortality among young chicks have been given some attention, especially the effect of musty grains when used as a part of their daily ration.

Some trap nest records have been kept in order that observations might be made as to the peculiarities in breeding, but owing to the lack of suitable equipment this work has been carried on at West Hartford. In order that more complete notes may be taken in this line, a new building is now being erected in connection with the college plant. This, it is expected, will be ready for use early this coming fall.

Respectfully submitted,

C. K. GRAHAM.

Report of the Mycologist.

To the Director of the Storrs Agricultural Experiment Station:

SIR:—Numerous questions arising in our study of the functions of fungi in cheese ripening already published have been followed up during the past year. Among these have been the inoculation of cheeses with mold, the preparation of stock cultures, the conditions of proper mold development, the problem of contaminating organisms and their control, and the whole series of questions involved in the classification and description of the species found. This latter topic has as before occupied all the time not demanded by the experimental work bearing directly upon the making and handling of the cheese.

Under authorization from the secretary of agriculture the mycologist was absent from Storrs from September 29, 1905, to January 16, 1906. After a short visit to the dairy interests in England, the meetings of the International Dairy Congress in Paris were attended in October. Cheese markets were visited in every country reached. This was found a very useful means of determining exactly what kinds of cheese were offered for sale, their relative prices in different lands, and especially the character and quality of the varieties of cheese which appeared in the different markets as representing the ideals sought by those peoples.

Special attention was given to the Camembert type of cheese. Enormous quantities of it were seen in markets and curing rooms of the trade. Factories in the neighborhood of Lisieux were visited including the one to which the origin of the name Camembert is attributed. The equipment and practice of the makers were seen as fully as time would permit.

Brief visits of a few days each were made to the makers of Stilton in England, to Roquefort in Aveyron, France, where the well-known Roquefort cheese is made, and to the region of

Lombardy in which Gorgonzola cheese is made and ripened. The information secured has been embodied in a report of the entire trip already submitted.

The final weeks were spent in mycological laboratories in Germany in consultation with different specialists upon the identification of the species of fungi already collected and studied.

Very satisfactory progress has been made in the practical application of our scientific results to the problems of cheese making in the past year.

Respectfully submitted,

CHARLES THOM.

Report of the Assistant Horticulturist.

To the Director of the Storrs Agricultural Experiment Station:

SIR:—Since taking up the work of the horticultural department in June of the present year several lines of investigational work have received attention. At this early date, however, very little reliable data can be produced.

The diversity of opinion as to the best methods of orcharding in New England and the varying degrees of success from such methods have made it seem advisable to investigate the subject. The first phase of the subject to receive attention was that of cover crops. The use of a ten-acre peach orchard was secured for the purpose, and twenty-five different crops are being tested.

With a view of securing definite information regarding the cost of renovating neglected apple orchards and of demonstrating the relative economy of the practice, a small neglected orchard in the vicinity of Storrs was leased. The process of renovating is now under way.

The young orchard started last year is being used to demonstrate the efficiency of the so-called grass mulch system as adapted to the rough, untillable land of the state.

Spraying experiments with potatoes, cucumbers and beans have been continued during the past season. Special attention has been given to the relative efficiency of arsenate of lead and Paris green for the potato beetle, and to ascertain the influence of Bordeaux mixture upon vegetation aside from its fungicidal properties.

Many inquiries from various sections of the state have been received in regard to an unaccountable injury to the foliage of apple trees. The most serious injury occurred in the vicinity of Storrs and especially in the college orchards. Examination revealed a small insect known as the Apple Leaf Miner (*Tischeria malifoliella*) and which burrows under the cuticle of the

leaf. It is likely to become a serious pest, for owing to its internal feeding habits, it cannot be controlled by the use of insecticides. With a view of discovering some vulnerable period in its life history a careful study of the insect in all its stages is being made.

I take this opportunity of thanking you for the willingness with which you have responded to my many requests, and at the same time I wish to call your attention to the inadequate facilities for thorough investigational work. One of the greatest needs of the department is a greenhouse where the many troubles of the in-door gardener may be investigated. The forcing of vegetables is becoming an important industry in the state and there is a strong demand for authentic information pertaining to the growing of greenhouse crops.

Respectfully submitted,

C. D. JARVIS.

Report of the Chemist.

To the Director of the Storrs Agricultural Experiment Station:

SIR:—The work of this department during the past year may be divided into three heads:

1. The investigation of the chemistry of soft cheese. This work is in charge of Mr. A. W. Dox whose report appears elsewhere.

2. The analytical work required in connection with experiments carried on by the other departments. This work has included the analyses of manure, feed, milk, and air.

3. An investigation of the solvent action of weak acid solutions on various soil samples. The method of analysis followed in this work was a modification of the method described by C. C. Moore (J. A. C. S., vol. 24, pp. 79–116). This work was started under the direction of Dr. B. B. Turner. Much of this work has been preliminary to a more extended study of soil fertility problems. A few details of this work are incomplete but I expect to present a report of the work at an early date.

The equipment of the department has been largely increased and the laboratory space more than doubled by a rearrangement of the room used in the cheese investigation, and the addition of a separate room for my work 15 x 17 feet, with large storage closets at each end.

Respectfully submitted,

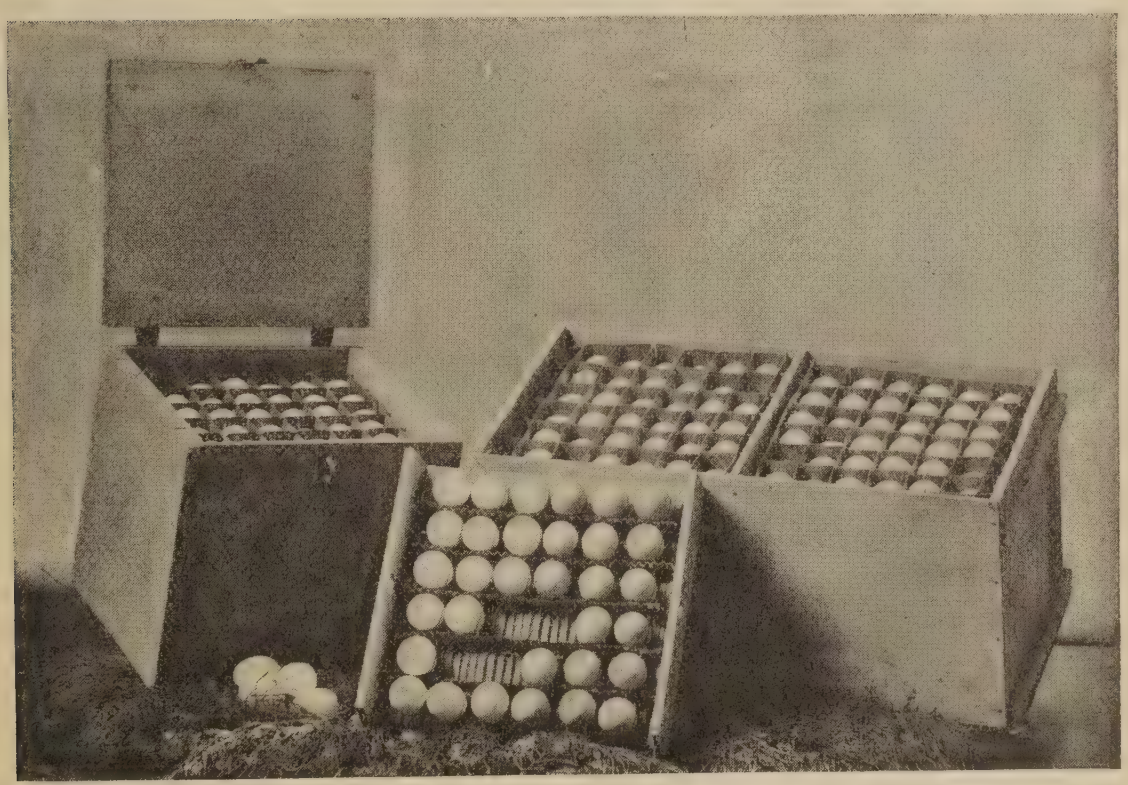
H. D. EDMOND.

STORRS

AGRICULTURAL EXPERIMENT STATION,

STORRS, CONN.

BULLETIN NO. 38, JANUARY, 1906.



THE MARKETING OF POULTRY PRODUCTS.

By F. H. STONEBURN.

THE MARKETING OF POULTRY PRODUCTS.

BY F. H. STONEBURN.

Poultry products of various kinds form one of the greatest crops produced upon American farms. According to the last census the value of the poultry products of the "farms and ranges" of the United States during the year 1899 was $218,178,035; and that, too, when reckoned at very conservative prices. This does not include the products of the village poultry yards, which, if added to the above, would very substantially enlarge the total. The ever increasing number of farms and plants devoted exclusively to poultry keeping produce large amounts of high grade goods, although these are inconsiderable when compared with the vast supply coming from the small flocks scattered upon the farms and in the villages throughout the country. Unquestionably the great bulk of poultry products has come in the past from the latter sources, and this condition is likely to continue.

Most farmers concede that their flocks of poultry yield them a fair profit; although any intelligent observer has but to spend a short time in investigating the great markets to learn that poor methods of preparing and marketing alone prevent the producer from receiving much greater returns. The majority of poultry raisers fail to realize that their profits could be largely increased, first, by the production of better and more uniform goods; and second, by improved methods of disposing of them.

Not infrequently it is stated that high grade goods sell themselves; and in a sense this is true. However, if the most satisfactory prices are to be obtained throughout the season, the question of marketing must receive due consideration. It is not enough to turn out superior goods; much is lost if they are not marketed in the most careful manner. The poultryman who receives the highest quotations for his products throughout the year is the one who studies "how, when, and

where'' to market. He learns that during certain months in each year there is a shortage of different kinds of poultry products, and he plans to produce as large a quantity as possible of these products during the season of scant supply. He then ascertains in which markets he can dispose of these goods to best advantage, and prepares and packs them according to the requirements of those markets.

WHERE TO SELL.

Poultry products are concentrated and valuable, although not extremely perishable. Therefore, improved means of transportation make it possible for the poultryman to place his goods in the best markets without greatly increased expense.

The best trade in the great cities pays the very highest prices for all kinds of poultry products, but this trade is difficult to secure and can be held only by those able to ship stated quantities of their special products regularly during the year, or at least throughout the season when such products are in demand. It is, therefore, usually a waste of time for those who can ship only at uncertain intervals to attempt to handle this trade.

While the very highest prices can be obtained in the larger centers of population, it is frequently a fact that better average prices can be secured throughout the year in the smaller cities. This is due to the fact that the great cities serve as distributing points, the less important markets drawing from them a portion of their supplies. However, this involves extra expense. Additional transportation, commission, and other charges, of necessity make the prices higher than at the distributing point, and this extra amount may often be secured by shipping direct to the point of consumption.

Nowhere in America can be found better markets for poultry products than in New England and New York, and all these are readily available to the poultry keepers of New England. This is an advantage the value of which is usually appreciated only by producers located in the less favored sections.

According to his opportunities the poultryman may choose from several methods of disposing of his products:

1. Selling direct to the consumer.

2. Selling direct to the retailer.

3. Shipping to commission merchants for sale upon the open market.

SELLING TO THE CONSUMER.

This is usually regarded as the most profitable method of disposing of high grade goods, because all of the charges and commissions of middlemen are eliminated. Frequently the producer is so situated that in the neighboring city or village he can work up a retail route and deliver his goods direct to the customer. As a rule a substantial increase may be secured over the prices paid by stores and markets. This premium may make all the difference between small and large profits, as the cost of production remains the same regardless of the selling price. The great disadvantage of the retail route lies in the fact that much time is consumed in soliciting orders and delivering the goods. This extra cost may be distributed if one or more allied branches are handled at the same time; e. g., milk, butter, vegetables, and fruit. Usually a brief investigation will enable one to decide whether or not the additional receipts obtained by this method of selling will pay for the extra time required to conduct it successfully. This special trade demands the regular delivery of goods of uniformly high quality, and it is not advisable to attempt to handle it unless one has sufficient facilities and ability to produce a regular supply.

Often it is possible to secure retail customers in a city within reasonable shipping distance, expressing to them at certain intervals stated quantities of eggs and dressed poultry. Weekly shipments seem to be most convenient. This is usually a decidedly satisfactory arrangement, as the producer has only to drive to the express office once each week to deliver all orders, and the customer is reasonably sure of a regular supply of fresh products.

Hotels, restaurants, clubs, and hospitals are excellent customers, and very frequently they contract for their supplies in this way. As a rule such institutions are willing to pay good prices, and their trade is desirable because heavy supplies are needed and it is easier to ship the entire output of a farm to one large customer than to divide it among several who use small quantities.

SELLING TO RETAILERS.

Grocery and provision dealers who cater to a select trade are usually glad of an opportunity to secure regular supplies of fresh eggs direct from the producer. Similar arrangements can often be made with marketmen for the disposal of dressed poultry. Frequently the prices secured in this way compare very favorably with those received from consumers, and under these conditions this trade is most desirable.

SHIPPING TO COMMISSION MERCHANTS.

The simplest method of disposing of all kinds of produce is to consign to commission firms for sale upon the open market. This does away with the expense and trouble involved in working up a private trade and with the necessity of making shipments at stated intervals, but the returns are not as great except in special cases where certain commission houses have built up a fine trade in given lines. Some make a specialty of high-grade eggs; others of prime dressed poultry, and hence such firms are frequently in a position to dispose of select goods at figures equalling or exceeding highest official quotations. These houses are invariably anxious to receive regular shipments from producers whose goods are of uniformly high quality, and will usually give such shippers the best of service.

The amount of commission varies, but as a rule it is 5 per cent. of the gross receipts. Frequently eggs are sold at a stated price per dozen, one-half cent to one cent being the ordinary fee. Cost of transportation is invariably charged to the shipper.

QUOTATIONS.

Official quotations are fixed in all large markets by a committee of the Chamber of Commerce or some similar organization and are based entirely upon supply and demand. These quotations are published in most important markets and can be secured by applying to any commission merchant. Some newspapers make a specialty of their market reports, and the quotations found therein are usually reliable, differing but slightly from those issued as above.

EGGS.

No special poultry product can be marketed throughout the year to such good advantage as eggs. When gathered from the nest they are a "finished product" ready for packing and shipment without the intermediate processes of dressing and cooling which so greatly trouble the seller of dressed poultry. The farmer or poultryman who makes a specialty of producing

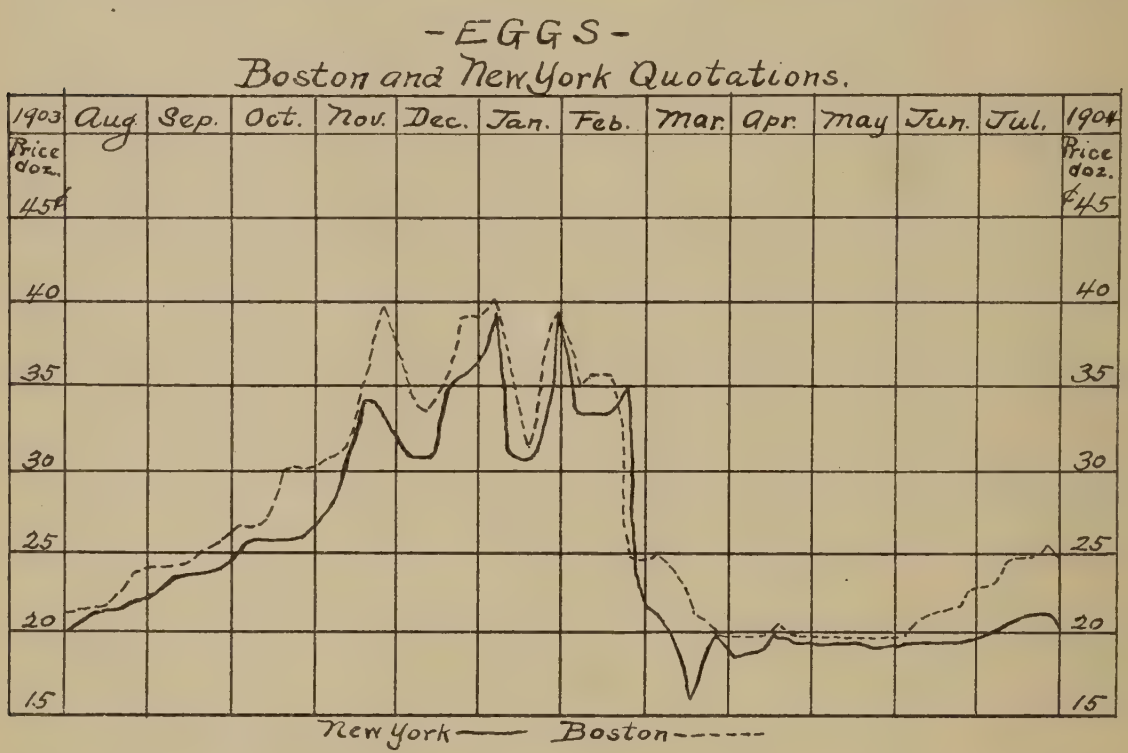


Fig. 1.

This and other similar charts used in this bulletin are based upon quotations given in The Producers' Price Current of New York and the reports of the Boston Chamber of Commerce. In each case highest quotations have been used.

market eggs can estimate within a very few cents the price they will bring him throughout the year, an advantage possessed by no other farm product. With almost the regularity of a pendulum egg prices swing backward and forward according to season, as a careful study of market reports covering several years clearly demonstrates. Generally the period of lowest prices begins the latter part of March or in early April and continues well into May. This is the natural breeding season of the fowls and therefore the period of greatest production. The period of low prices varies somewhat from year to year, an early spring hastening the drop in price, and a late one

retarding it. As the fowls become broody the production begins to drop off, and large numbers of eggs are incubated, thus further reducing the supply available for consumption. Prices then take an upward turn, rising gradually from May to September, when a large proportion of the adult fowls go into molt and practically cease egg production. From this point the rise is rapid, reaching the highest point in December and January and dropping rapidly during February and March as the spring flood of eggs begins to reach the market. The above outlines the general trend of prices year after year, with occasional sharp breaks or rises due to periods of weather favorable or unfavorable for egg production. In the accompanying chart will be noted some such sudden changes in quotations, which soon thereafter return to the normal point.

During the period of heaviest production vast numbers of eggs are placed in cold storage for preservation until the season of scant supply. This system really acts as a balance-wheel, as it absorbs all surplus at a fair price. There is no doubt that, without this or some similar method of preservation, egg prices would go to a ruinously low figure every spring, as at that time production is greatly in excess of consumption.

There is a fashion in eggs as in other things. In Boston, Providence, and other important New England markets the fancy trade demands brown-shelled eggs, while in New York and the markets dominated by that great city best prices are received for eggs with white shells. Logically, then, the egg producer who desires to cater to this best trade should keep only those varieties of fowls which will yield him eggs meeting its requirements, even though he is personally convinced that the brown-shelled egg is as good as the white-shelled, or that it is not.

PRICES.

When eggs are placed upon the open market they are usually sold at the ruling price of that day or at a slight decrease from or advance over this price according to the ability of the salesman. In contracts with private customers, however, it is far better to have the price definitely settled in advance. Many customers, in order to be sure of their supply of fresh eggs throughout the year will contract for a stated number to be

delivered each week during the entire year at a flat rate per dozen. This method is satisfactory in many ways and avoids any possible difficulty or misunderstanding arising regarding the amount of the bill. In order to handle customers of this kind, however, the producer must be in position to secure a given number of eggs each week throughout the year, as he can rest assured that the customer will insist upon having his full shipment during the season of least production, which is also that of highest price. Therefore contracts of this kind must be made with particular reference to the season of smallest production.

A common method of fixing prices is to make a schedule of prices to be in force during different months of the year. Such a schedule can easily be arranged by referring to quotations of previous years. Under such an arrangement the consumer knows exactly what eggs will cost at any season of the year and can thus order intelligently.

Perhaps the most satisfactory method of fixing the price is to base it upon current market quotations, adding a stated amount per dozen as a premium. This amount varies considerably, five cents per dozen being a common premium, with eight and ten cents frequently secured. There should be a definite understanding between both parties to the contract as to the source from which quotations are to be taken. Otherwise trouble is likely to arise over the bill because of each party taking different quotations.

Occasionally an arrangement is made whereby the producer receives a premium based upon the market price of the eggs instead of upon the dozen, a certain percentage of the market price being added. In some instances the producer secures as high as fifty per cent. increase in this way, receiving thirty cents per dozen when eggs are quoted at twenty cents, and sixty cents when they reach forty on the open market.

Eggs placed upon the open market should be sorted and packed most carefully. Reject all that are small or unusually large in size, also those of poor shape and with imperfect shells. All eggs should be perfectly clean. If slightly soiled they may be wiped clean with a damp cloth, but if badly soiled they should be discarded. The washing required to clean eggs which are very dirty injures their appearance decidedly.

Egg packages should be selected with reference to the needs of the particular trade for which they are designed. When eggs are delivered to consumers in lots of a few dozen, the small pasteboard carton with a capacity of one dozen eggs is a decidedly neat, convenient, and popular package. These are made in a variety of forms, one kind being fully illustrated in frontispiece. Their cost, including printing of cover, ranges from $5 to $7 per thousand, according to quantity. Such packages are especially desirable for use in private trade and form a constant advertisement for the up-to-date poultryman.

These cartons are also desirable for use in making express shipments to private customers, especially when placed in attractive shipping cases. The three-dozen size is constructed as follows: It is 11½ x 12 inches inside measure and 4 inches deep. The material is any light, well seasoned wood, whitewood or white pine being most satisfactory. Hard pine may be used if an exceptionally nice finish is desired. The ends are ⅞ inch, and the sides, bottom, and cover ⅜ inch in thickness. The cover is reinforced with two strips of ½ inch thickness to prevent warping and splitting. The entire case is further strengthened by tacking a ½ inch strip of galvanized iron around each end. A 2½ inch hasp and 2½ inch strap hinges secure the cover, which is also equipped with a lightweight, cast-iron handle for convenience in handling the package. The capacity of this case may be increased in multiples of three dozen by simply making it deeper according to the number of layers of cartons desired. Fifteen inches in depth will accommodate five layers—fifteen dozen of eggs.

After completion the case should receive a good coat of paint or be oiled and shellacked, according to the material of which it is constructed. Finally the name and address of the poultryman or farm should be plainly marked upon the top and end of the case, this being most easily done by means of a stencil.

The case described above is 4 inches deep, while the depth of the carton is but 2¼ inches. The remaining space is designed to permit the use of plenty of packing material to avoid loss by breakage enroute. Dry, clean excelsior is the best material for this purpose, although clean hay or straw will prove satisfactory. A liberal amount of packing material should invariably be used in each package of eggs shipped by express, regardless of its size.

Retailers often appreciate having eggs packed in cartons, as they can then sell them in these original packages just as they come from the farm. This permits the fixing of responsibility in case the goods prove unsatisfactory. Large consumers and the commission houses usually prefer that eggs be packed in the standard thirty dozen case with pasteboard fillers. When so packed they are easier to remove from the crate, and this is quite an item where large numbers of eggs are handled daily.

There are several cases upon the market which are fitted with trays having wire loops or springs to hold the eggs in place. This arrangement permits the eggs being attractively displayed, but is not popular for several reasons: They are more expensive than regular cases; they often become unserviceable because of bent wires which do not hold the eggs firmly; and much time is required to fill and empty them, as each egg must be handled separately.

Standard egg cases can be purchased second-hand at from five to ten cents each, complete with pasteboard fillers. Bakers, hotels, and large provision houses handle great quantities of cold-storage eggs, and the cases are usually sound and clean because of cold-storage requirements. One firm in New York makes a specialty of second-hand egg cases, securing them from consumers and selling in large or small lots to meet the requirements of each purchaser. The removal of the former stencil and the addition of a new one take but a moment, when a case of this kind becomes practically as good as new.

Formerly the express companies returned empty cases free of charge, and shippers often preferred to use special cases of superior construction. Under a recent ruling, however, each express company handling a returning empty collects five cents. This charge practically equals the cost of second-hand cases when the empty case is handled by one company only, and exceeds it when handled by two. Therefore it is often economy when selling eggs upon the open market to let the case go with the eggs and not have it returned at all. However, if the shipper prefers special cases he can have them built, or can build them himself, preferably in shape and size similar to the standard case. These can be returned and repeatedly used.

Shippers frequently complain that the eggs they consign to commission merchants sell at a price lower than the quotations

for extra stock. This may be due to poor service on the part of the seller, or, what is more frequently the case, the goods are not of sufficiently high grade to command the best price. The New York market has long regarded the eggs of White Leghorn fowls as the standard of excellence. Such eggs are good sized, of fine shape, and are chalky white. When properly culled as advised above such eggs will "top the market." The requirements of the Boston market, as set forth by a leading commission firm making a specialty of eggs, are as follows:

"Extras—Large, brown and fresh in every way. Weigh 2 lbs. or more per dozen.

Firsts—Good eggs as regards color (brown), fair size. Weigh 1¾ lbs. per dozen.

Ordinary—Mixed. Weigh 1½ lbs. per dozen."

From the above it will readily be appreciated that while "eggs are eggs," as some express it, a discriminating market strictly classifies them and will pay first-class prices for none but first-class goods.

When selling to private trade it is frequently considered desirable to stamp the farm name upon each egg, but commission houses object to this except in special instances.

When sound eggs are carefully packed in strong crates as outlined above and shipped by express, there should be practically no breakage. If many eggs are broken, it indicates rough handling by the express company, which is responsible for the loss. Claims for breakage should be filed promptly, and, as a rule, settlement can be easily effected.

Eggs intended for cold storage should be sound, full, and perfectly fresh, and be packed in standard thirty dozen cases. The latter, together with the fillers, must be perfectly clean and free from mold and odors of every kind. When so packed they sell readily during the packing season.

LIVE POULTRY.

In all large cities there is a constant demand throughout the year for all kinds of live poultry. A large proportion of this live stock is absorbed by the Jewish trade, as orthodox Jews will not use meat of any kind unless it is killed by a certain method under the direction of a rabbi. Each large market has

a slaughter-house where animals and birds are slaughtered according to these prescribed rites. The best prices for live poultry are secured at the time of the Jewish holidays, the dates of which vary from year to year. They can be ascertained through any commission house or dealer.

Occasionally the price of live poultry is nearly as high as for dressed stock, and under these conditions it is a waste of time to dress the birds before shipment. This is particularly true if the market is near at hand, as the birds will not shrink much when being shipped but a short distance.

For shipping live poultry to market well constructed crates are particularly desirable. They should be of sufficient size to avoid causing discomfort to the birds, yet small enough to permit easy handling by expressmen and others. Long crates should be equipped with solid cross-partitions to prevent the birds being thrown together at one end when the crate is tipped in handling. Failure to observe this simple precaution often results in the loss of a number of birds in each shipment. All crates should be thoroughly ventilated, as in crowded express cars they are frequently piled one above another, and many birds are smothered in this way.

Express companies will return empty crates at a cost of ten cents per crate for each company handling them. Whether or not it is wise to have empties returned must be decided by each shipper according to the conditions surrounding his case. Western shippers send large quantities of live birds to the eastern markets in large, rough-board crates, which are never returned, as they are not worth the return transportation charges.

All live birds shrink more or less in weight while enroute to market. Turkeys and large, soft chickens show the greatest percentage of loss, and old fowls the least.

The last thing before shipping, the birds should receive plenty of water. They should also be given a liberal amount of feed, preferably some whole grain, as corn and wheat. Should the journey be a long one, some additional feed may be placed in the crate. Live poultry should never be shipped to reach the market later than Friday morning, and Thursday morning would be safer.

DRESSED POULTRY.

Much poultry that would sell at highest quotations if properly dressed is of necessity sold at unsatisfactory figures because of carelessness or inefficiency on the part of the dresser. The value of dressed stock is in large measure determined by its appearance. A plump, good-colored, well-grown bird will depreciate greatly in value if not carefully dressed. Half-plucked or badly-torn birds are not desired by the trade that pays the high prices.

The easiest way to dress poultry is to scald it. If this is properly done, the feathers can be removed with great rapidity, and the skin is seldom torn. Private customers are frequently willing to accept scalded birds, and in some sections, particularly in the smaller markets, these move readily upon the open market. Marketmen generally object to handling scalded stock, however, as they consider that such birds do not keep as well as when dry-picked and are less attractive in appearance. The skin is usually badly discolored in places, and the birds soon become "puffy" when exposed for sale. The Boston market in particular insists that all stock shall be dry-picked, and although New York will handle a certain amount of scalded stock, the best prices are obtained there for that which has been dry-picked.

KILLING.

The birds which are to be killed should be kept without food long enough to insure the complete emptying of their crops. This is extremely important, as food left in the crop sours quickly and soon makes the stock unfit for use and thus subject to confiscation by the state or local boards of health. A fast of twelve to twenty-four hours will serve to empty the crop and in large measure the entire intestinal tract. It is well to confine in comfortable coops for that length of time all stock that is to be dressed. This prevents it from getting food aside from that intentionally fed. During this time plenty of water may be supplied, as this keeps the birds comfortable and prevents loss of weight. Should water be present in the crop at the time of dressing, it may be forced out by holding the fowl head downward and squeezing the crop.

Practically all dressed poultry marketed in the large cities is sold undrawn and with the heads and feet left on. For this reason the killing should be done in a manner which will not injure the appearance of the carcass. The old "axe and block" method is quick and effective, but hardly meets the above conditions. Sticking the bird in the mouth and throat with a sharp, narrow-bladed knife is certainly the best method of killing for the American market. (A great deal of the poultry designed for the English market is killed by dislocating the neck.) Poultry of all kinds is killed in the same way. The necessary "tools" are a knife with a long, narrow blade, a short, heavy club, and some receptacles to catch the blood. For the latter nothing is better than small tin pails or large tin cans equipped with wire bails. To each bail should be attached a sharp-pointed, heavy-wire hook, by which the receptacle may be suspended from the bird's lower jaw and thus catch the dripping blood. This arrangement serves two purposes. It prevents the struggling bird from throwing blood over the operator and the room, and it also saves the blood for further use.

The actual killing of the bird is a simple operation, but for it to be entirely successful two things must be secured, thorough bleeding and speedy unconsciousness, with attendant relaxation. Suspend the bird by the feet at a convenient height by means of a strong cord, having an easy running slip noose. Take it firmly, head to the front, under the left arm. Held in this position, its struggles will not interfere with subsequent operations. Take the head in the left hand, forcing the bill open with the first and second fingers. Insert the knife in the mouth, carrying the point well back, and make a deep cut across the upper part of the neck at about the point of junction with the skull. This should sever the large blood vessels located at that point, and if blood immediately runs in a steady stream, the cut has been properly made. The bird should now be stunned in one of two ways, sticking in the brain or striking with a club. The former is the best after once learned, but is more difficult for the novice, as it seems necessary to pierce a certain portion of the brain in order to secure the coveted result—a relaxation which releases the feathers and permits rapid picking without great danger of tearing the skin.

When piercing the brain in this way, do not withdraw the knife after cutting the blood vessels, but thrust it up through the roof of the mouth into the back part of the brain and give it a half turn. Then insert in the lower mandible one of the hooks attached to a small receptacle, as described above, and all of the blood will be caught. Should extra weight be needed to keep the bird's head still, it may be secured by partially filling the pail with corn meal. If the stunning is to be done with a club, use the knife to start the blood as directed above, and then hook the pail into place. Next grasp the bird by the wings or body and strike it a sharp blow upon the back of the head, thus immediately rendering it entirely insensible to pain. A sudden spasmodic stiffening of the muscles is the sign that the blow has been effective. Strike squarely, as a glancing blow will often peel quite a piece of skin from the head, making it unsightly.

Although stunning the bird is not necessary when the feathers are to be removed by scalding, it certainly is more humane to do so.

SCALDING.

The receptacle in which the scalding is done should be of sufficient size and depth to permit the body of the bird being entirely submerged. The water should be hot, not quite at the boiling point, but near it. When many birds are to be scalded it is decidedly convenient to keep the scalding-tank upon a fire sufficiently hot to maintain the temperature of the water at the right degree.

After the bird has practically finished bleeding, take it by the head and feet and immerse it in the water, once with the back upward and once with the breast, leaving it in the water but a very short time. The head must not be placed in the water, or it will soon appear dark and shrunken. Usually twice dipping will suffice to properly start the feathers, when picking should immediately begin. Again hang the bird up, and pluck the feathers as rapidly as possible. Use extreme care not to rub the skin, as it will surely become discolored wherever this occurs. As soon as the feathers are entirely removed, the carcass should be plunged again into the scalding

water, left there for several seconds, and then placed in cold water to cool. This process is technically known as "plumping," and it greatly improves the appearance of the carcass.

If the stock is to be iced when shipped, it can remain in this cold bath until taken out for packing. Otherwise it should be removed when thoroughly cooled and hung up to dry. Never hang the birds in a direct draught, as they will become "wind-dried," which is not desirable.

DRY PICKING.

Dry picking usually gives the beginner considerable trouble. Cramped fingers, backache, and discouragement are merely incidentals. But every market poultryman should learn the process, and this comes only by practice. After a time a certain "knack" is acquired, and the work becomes easy. Much of the success of dry picking depends upon how the bird has been killed. If properly stuck in the brain or struck with the club, the feathers may be removed with comparative ease. Otherwise they will frequently act as if clinched under the skin. It is not to be expected that a bird will not be torn occasionally. The most expert pickers have frequent accidents of this kind, as often a bird will be picking easily and smoothly, and then for some unexplainable reason the skin will tear. The best thing to do, then, is to work carefully when picking the portions of the body most liable to tear, and hurry on the remainder.

Have the bird hung at a convenient height, neither too high nor too low, as either height becomes tiresome before many birds have been dressed. Most pickers prefer to work with the bird about opposite the elbows. Begin to pick immediately after the bird has been stuck, as the feathers come easier while the blood is flowing. Operators differ in their ideas as to which portions of the body should be plucked first, but many experts work as follows: First, the coarse feathers of the wings are removed, one sweeping motion of the hand usually being sufficient for each wing. The tail feathers are next snapped out. As the breast is the most tender part and the one most easily torn, it is next attacked. On each side of the breast bone lies a narrow strip differing in appearance from the rest of the breast, and these are extremely tender. After the

feathers have been removed from them, the rest of the breast can be picked without great trouble. Next come the thighs, and here, too, are found some small tender spots which must receive careful treatment. The wings follow next in order, and they usually cause no trouble except at the joints. Finally the back is stripped, and the carcass is ready for pin-feathering. It is a mistake to grasp a handful of the body feathers and attempt to remove them with one pull, as a tear usually results. The same feathers can be removed without danger by a rolling motion of the hand which is hard to describe, but which once learned is never forgotten. A dish of water in which to dip the hand is a great convenience to the picker, as damp fingers give a much better grip on the feathers.

During the process of picking, the worthless feathers should be discarded by being thrown upon the floor, while all that are salable should be caught in a barrel or box directly beneath the bird and the hands of the picker. This is very convenient, and the danger of soiling the feathers with blood is eliminated by the use of the pail as described above.

A common stool can be used while working at birds hung up by the feet, if it is considered desirable to sit while picking. If this is unsatisfactory, proceed as follows: Kill the bird as directed above, and take the body across the knees, holding the head firmly between the right knee and the feather-box, the latter being knee-high. Use the left hand to hold the body, turning it in the most convenient position, and with the right remove the feathers. Most rapid pickers prefer to stand while at work, as both hands can be used to better advantage.

As before stated, the appearance of the carcass in great measure determines its value, and hence careful pin-feathering becomes important. Unless the stubs and pin-feathers are practically all removed, the carcass will be anything but attractive. A short, dull knife is a great aid while removing "stubs" and "pins."

After the picking is finished the birds may either go into the cooling tank or be hung up to cool, according to the weather and the way in which they are to be packed for shipment.

DRAWING.

As stated elsewhere, practically all dressed poultry should be shipped to market undrawn. Most commission men and dealers prefer to handle undrawn stock, claiming that it keeps much better. The basis for this claim is that the incision in a drawn fowl readily admits molds and germs of different kinds into the body, where they find ideal conditions for rapid multiplication. The cavity is dark, damp, and not easily accessible, and frequently a drawn bird which outwardly appears all right is really unfit for food. As it requires considerable time to draw the birds contained in an ordinary shipment, and there is a decided loss in weight as well, stock should be shipped undrawn whenever the market will accept it.

When birds are to be drawn, the operation should be performed immediately after the pin-feathering is finished or after they have become slightly cooled, as it is more difficult after they are thoroughly chilled. A sharp knife is essential, although some dressers prefer to make the necessary incision with curved scissors similar to those used by surgeons. Drawn fowls usually have the head removed also, and this should be done first. Sever the neck close to the head, taking care not to cut the windpipe and gullet, which can be more easily pulled out if left attached to the head. Draw the neck skin back and remove a short section of the bone, thoroughly washing out any blood which may collect. Finally draw the skin forward, and tie firmly. Remove the intestines through a small opening, as a large aperture is unsightly as well as unnecessary. Cut carefully through the walls of the abdomen, making the incision entirely around the vent, then hook the first finger into the loops of the intestines and thus pull them out. Usually the heart, liver, lungs, and gizzard are left attached in their natural position, as ordinarily the removal of the intestines is considered sufficient. After this has been accomplished the cavity should be thoroughly rinsed to remove all blood and other secretions.

A select private trade often demands that poultry be even more carefully prepared, in which case the giblets should be removed and cleaned. Cut the gall-sack from the liver, the blood vessels from the heart, and remove the contents of the gizzard. Cut off the shanks after first removing the strong

sinews which run up through the leg and injure the quality of the "drum stick." To take out these sinews run a knife blade down the back of the bone of the shank, between it and the sinews. Remove the skin above the sinews, and pull the latter out singly by means of a strong fork or skewer. A still easier way is to have a strong hook fastened to the wall at the proper height. Place the point of the hook under each sinew, which can then be easily drawn out. See Fig. 2. The bird is

Fig. 2. Drawing the tendons.

now ready for tying up. Replace the giblets in the body cavity, draw the end of the drumsticks down to the "pope's nose," and there tie firmly. Finally fold the wings behind the back. Birds so tied are unusually attractive, always appearing plump and chunky, due to the absence of sprawling legs and wings.

Broilers may be attractively prepared for private trade as follows: Pluck carefully, and remove the legs and sinews as above. With a heavy, sharp knife make a cut each side and the entire length of the back bone, severing the ribs. Let these incisions meet in front of the neck and below the vent. This permits the removal of the head, neck, back bone, and entire intestinal tract, and the bird opens out flat in most convenient form to be placed upon the broiler. The giblets should be cleaned and should accompany the remainder of the carcass.

PACKING—PACKAGES.

Every bird should be thoroughly cooled before being packed for shipment. It takes longer to entirely remove the animal heat than the uninitiated would believe, but if it is not done thoroughly the stock is very likely to spoil in the package. Much loss is caused by negligence at this point. Never let the dressed stock freeze, unless it is to be retained for some time and sold as frozen stuff. Thawing injures the quality, and decay soon follows. Birds shipped without ice should be *entirely dry* before packing.

Careful grading of stock designed for the open market is very important. A few scrawny or badly-torn birds will often spoil the appearance of a shipment which would otherwise be excellent, and a lower price must be accepted. Keep the inferior stock separate from that which is desirable. Each grade will sell to better advantage if kept separate from the rest.

Inspect each bird carefully before packing. Wash the feet, remove the clotted blood from the mouth, and wash the head. Sew up any bad tears in the skin, using fine white thread for this purpose. A curved needle is more convenient for this work than a straight one.

Birds which have a dark or dingy appearance can often be greatly brightened by washing in a strong suds made of some good soap or washing-powder. Water fowl in particular can be much improved by special cleaning. An ordinary hand-brush is convenient to use for this purpose.

Packages for dressed poultry vary greatly, but should meet two requirements. They must be neat and clean, and small

enough to permit easy handling. For delivery to retail customers pasteboard boxes of sufficient size to hold a single bird or one pair are desirable. The birds should be wrapped in clean paper, preferably waxed paper, before being placed in the box. Retail egg customers whose supplies are shipped by express may be served with dressed poultry by using an egg case built like the standard case, one end being used for eggs and the other fitted with a metal box in which to place the birds. In warm weather sufficient ice may be included to insure arrival in good condition.

Barrels of various sizes are popular packages, especially when ice must be used. Pack them with alternate layers of ice and birds, the bottom and top layers invariably being ice. Upon the top place a good sized block of ice, which will melt, causing the ice water to continuously trickle down through the layers of birds beneath. Cover the top with a piece of burlap, fastening this by means of a hoop. Cases may be filled with ice and dressed poultry in the same manner, and in some respects are preferable to barrels. The stock can be packed in cases in better shape than in barrels. Burlap tops should be used on cases of iced stock, as well as on barrels, as all packages so covered will be kept right side up.

Stock shipped without ice should be packed in clean cases which should be lined with fresh wrapping paper. Some careful shippers wrap each bird in waxed paper, and such care usually pays, as the stock so packed reaches market in the best of condition. Occasionally birds will soften up so much enroute that blood will run from the mouth, thus soiling much of the contents of the case. To prevent this a piece of paper may be wrapped around the head of each bird.

Mark all packages with the name of the shipper, kind and number of birds, and net weight.

No shipment should be made to reach the market later than Friday morning, except by special arrangement with the dealer.

All birds should be plucked clean, except as mentioned in the succeeding paragraphs. Ducks, geese, and squabs should have *white skin;* broilers, roasters, etc., are preferred with yellow skin and shanks.

BROILERS.

The first fresh broilers of the year appear upon the market in January. These birds weigh from 1½ to 2 pounds per pair, and are known as squab broilers, club-house broilers, and individual broilers. They are used largely in hotels, restaurants, and clubs, and the demand for them seems to be increasing. With May comes the call for larger sizes, and soon birds weighing 4 pounds per pair are desired. The first birds in the

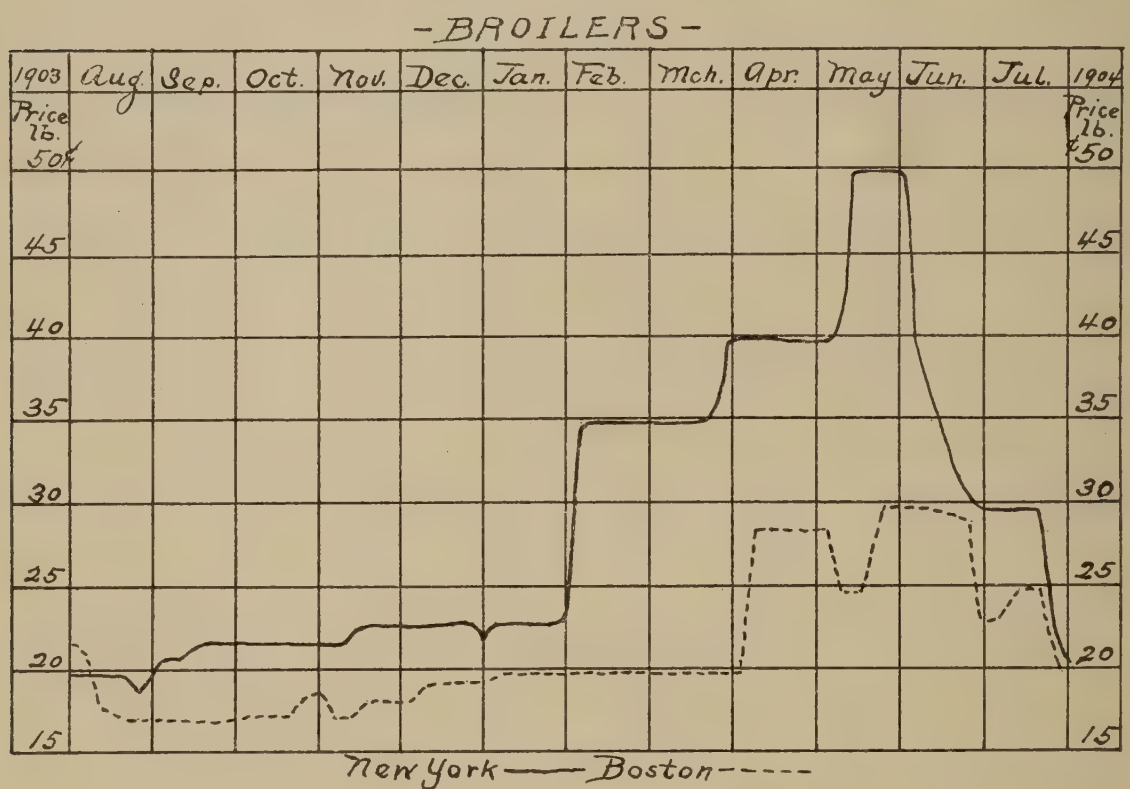


Fig. 3. Boston and New York quotations.

market bring the best returns, the price steadily decreasing as the supply becomes greater. Broilers find a steady sale during the entire year, but for some months each season the main supply comes from cold storage. This system of preservation is perfected to such a degree that practically all kinds of poultry products can be secured at any time regardless of the amount of the fresh supply available.

ROASTERS.

Chickens weighing 8 pounds or more per pair are usually called roasters, although in Boston the word "chickens" is much used in place of the other term. The highest prices are paid at the season of scant supply. In order to secure these

high prices some market poultrymen, particularly in the vicinity of Boston, reverse the usual procedure of hatching in the spring and selling the product in the summer and fall. They hatch in the fall and early winter, grow the chickens during the winter months, and place them upon the market when there is an entire absence of stock. As a result most satisfactory prices are obtained, frequently from 35 cents to 40 cents per pound wholesale. The highest grade of broilers, roasters, and capons is known as "Philadelphias," regardless of the section from which the birds are shipped.

FRYS.

In some markets chickens intermediate in size between broilers and roasters, about 6 pounds per pair, are termed "frys." Prices obtained for stock of this kind are usually low.

FOWLS.

There is a steady demand for fowls at all seasons of the year, and usually the price shows comparatively little variation, certainly never covering the wide range of broiler and

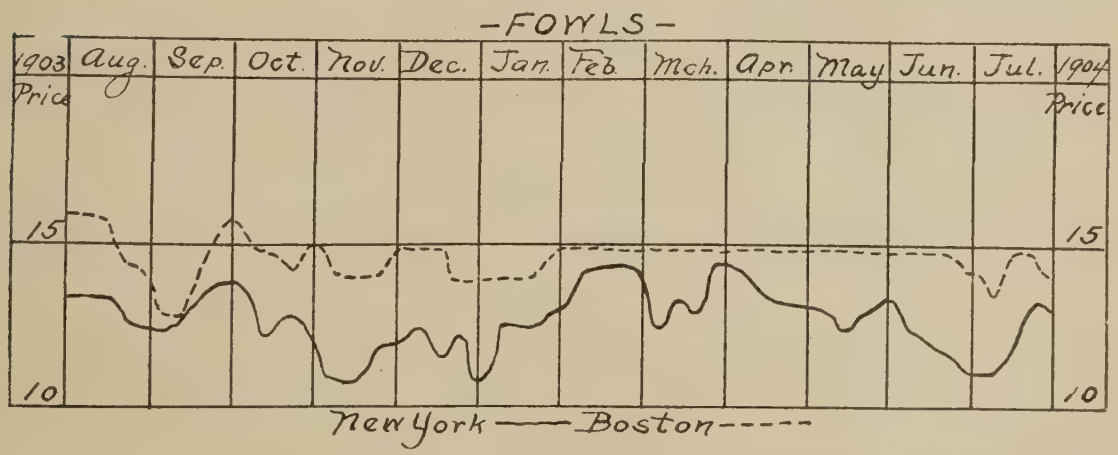


Fig. 4. Boston and New York quotations.

roaster prices. The market term "fowls" refers to hens, the old males being classed by themselves as "roosters," selling at very low prices.

CAPONS.

Two capons, one being a Philadelphia, are illustrated in Fig. 5. The call for fresh-killed capons begins in December and continues the greater part of the summer. Highest prices are usually secured about January 1st. These birds are

Fig. 5. Capons ready for market.

dressed in a showy way, feathers being left upon the neck, rump, wings, and thighs. The head should never be removed from a capon, as its peculiar appearance is a distinguishing mark.

TURKEYS.

The turkey is essentially a holiday bird, and although in demand throughout the year, sells for the highest prices at

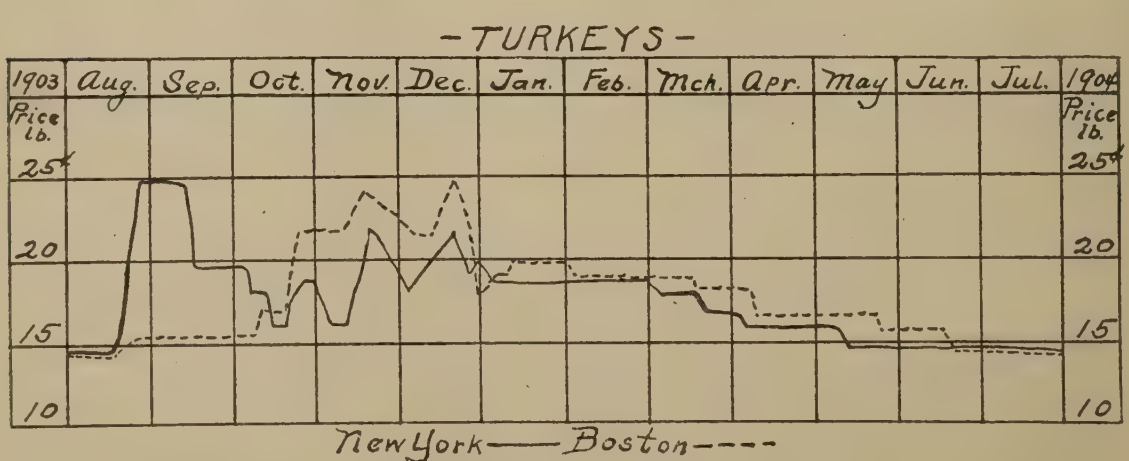


Fig. 6. Boston and New York quotations.

Thanksgiving and Christmas. Shipments of turkeys should be timed to reach the market several days in advance of these holidays. Turkeys may be plucked perfectly clean, or feathers left upon the neck, rump, and first joint of the wings.

GEESE.

Hotels, particularly at summer resorts, are the greatest consumers of green geese. Prices are best through the summer and fall months, and the first green geese to reach the market usually sell at the highest figure of the year. Feathers are left upon the lower joint of the wings and a part of the neck. The wings should be tied tightly to the body with a strong cord.

DUCKS.

Throughout the summer and fall green ducks (ten to twelve weeks of age) are in great demand, and adult stock moves readily the entire year. As usual, the best prices are paid for

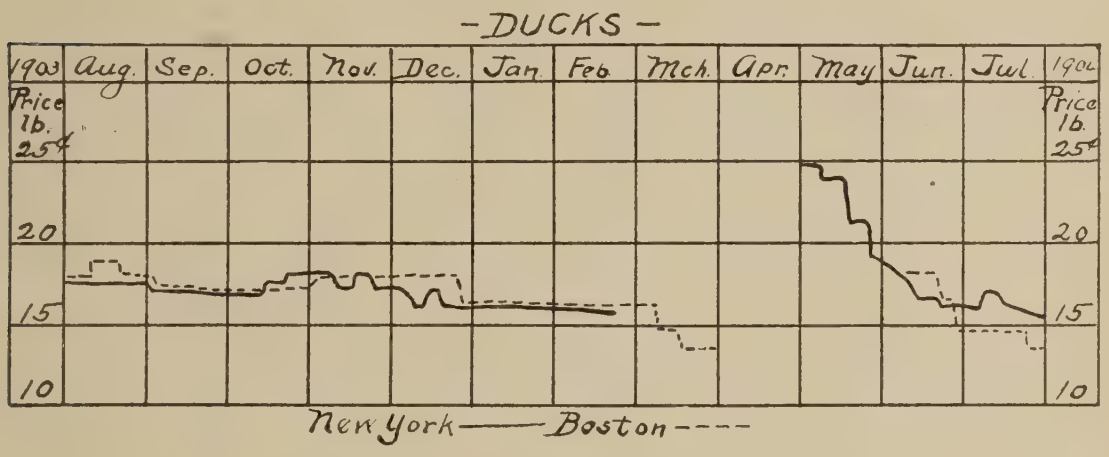


Fig. 7. Boston and New York quotations.

the first fresh stock offered for sale, quotations steadily declining as greater supplies arrive. Feathers are left as on geese, but the wings are seldom tied.

GUINEA FOWLS.

Of late there has developed quite a demand, particularly in New York, for young Guinea fowls for broiling. There is a small but steady demand for adult birds also. Most of this stock is sent to market with all feathers left on, the killing being done by sticking in the same manner as with other poultry. What few pheasants reach the market are also sent unplucked.

SQUABS.

The demand for squabs is continuous, and desirable stock moves readily at all seasons of the year. There are several market grades, and squabs are rigidly classified in the market.

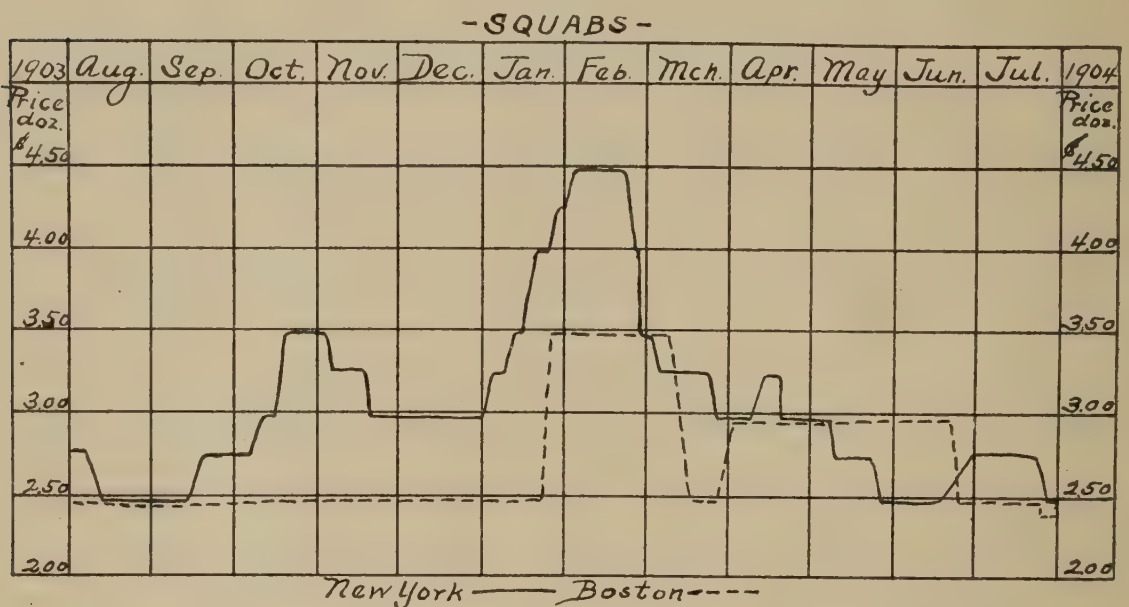


Fig. 8. Boston and New York quotations.

The most desirable birds are those which are plump and full-breasted and white-fleshed. Dark and thin stock sells for much less than the above grade. Squabs weighing 8 pounds or more per dozen are known to the trade as "Jumbos," and if light colored bring the best prices. Prices are highest during the fall and winter months, as at that time the supply is limited owing to the fact that the birds do not breed as frequently as during spring and summer.

BY-PRODUCTS.

Everyone who dresses poultry in any quantity should make it a point to save all the by-products. Reference has been made elsewhere to a simple method of securing the

FRESH BLOOD.

As this comes presumably from none but healthy birds, it may be advantageously fed to live poultry. Because of the high percentage of protein it contains, it is especially valuable as food for laying and young stock. It can be most conveniently fed by mixing in the mash feed.

FEATHERS.

Feathers of all kinds meet with ready sale. Prices vary with the kind and color of the feathers, as the subjoined quotations from a large dealer show:

"DEAR SIR:—We will pay you the following prices for feathers in prime, dry, merchantable condition:

Geese—Choice, pure white, 60c.; white, 55c.; largely gray, 42c.; goose quills, long, 15c.

Duck—Pure white, 42c.; white, yellow, or stained, 38c. and 40c.; colored, 33c.

Chicken—All white, 20c.; colored, 4½c.

Feathers are put to a great variety of uses, the principal one being as filling for pillows and cushions. Great quantities are used in making up millinery novelties, feather boas, and similar articles.

Turkey tail feathers, as well as those from the second and third wing joints, are much in demand by manufacturers of feather dusters, and quills from the first joint of the wing of the turkey are used in the manufacture of featherbone, a substitute for whalebone, for dressmaking and other purposes. Large supplies of these quills are used, there being over 600 people employed in one Michigan factory where this substance is manufactured.

The feathers from the hackles and saddles of the males of certain varieties of fowls are largely used in the manufacture of artificial flies for fishing. Such feathers usually bring from 50 cents to $1 per pound. Those from the black and red birds, like Brown Leghorns, Partridge Wyandottes, and Partridge Cochins, are particularly desired.

All feathers should be dried by being spread out upon a floor for some time, or placed in sacks and hung out in the sun and air. When shipped to market, they are usually packed in burlap sacks or light cases and sent by freight.

LOSS IN DRESSING POULTRY.

During the year 1903–4 several hundred birds were dressed by the Poultry Department of the Connecticut Agricultural College for use at the student boarding-hall. The stock was

of several varieties, and included cocks, cockerels, hens, and pullets. At the time of dressing each bird was weighed three times; alive, after being bled and plucked, and finally after the removal of the intestines, head, and feet. This stock was dressed upon call of the College steward and as a result included birds which were specially fattened, as well as those in poor flesh. Occasionally it was necessary to dress some which had not been kept without food long enough to empty the crop. Under these conditions it is evident that the figures secured may safely be taken as a fair average of the loss in dressing birds not especially fattened for market. The percentage of loss is less when birds are well fattened. The weighing was done by several persons employed at the Poultry Department, but the figures are undoubtedly accurate. The following tables may prove an aid in determining whether better returns can be secured from a given lot of stock if sold alive or dressed:

TABLE I.

Loss in dressing.

	No. of birds.	Live weight.	Weight—bled and plucked.	Per cent. loss.	Weight—intestines, head and feet removed.	Per cent. loss.
Cocks,	18	127.9	117.9	7.8	97.8	23.4
Cockerels,	278	1773.0	1577.5	11.0	1312.0	26.0
Hens,	201	1195.0	1103.4	7.7	906.3	24.2
Pullets,	47	261.1	240.0	8.1	193.7	25.8
Total,	544	3357.0	3038.8	9.4	2509.8	25.2
Barred Plymouth Rocks,	187	1199.9	1090.8	9.1	910.4	24.1
White Plymouth Rocks,	125	859.1	779.4	9.2	644.7	25.0
White Wyandottes,	103	618.2	558.3	9.6	460.8	25.4
Buff Wyandottes,	6	39.4	35.2	10.6	28.5	27.7
Rhode Island Reds,	18	109.7	98.0	10.7	80.2	26.9
Black Langshans,	32	200.5	182.7	9.9	151.4	24.5
S. C. White Leghorns,	22	88.3	78.0	11.7	62.1	29.7
R. C. Brown Leghorns,	35	129.6	116.0	10.5	90.4	30.2
Wh. Wyan.-Lt. Brahm. cross,	16	112.3	100.4	10.6	81.3	27.6

NOTE.—The manuscript for this bulletin was in part prepared by Prof. Stoneburn before he resigned his position as Poultryman for the Storrs Experiment Station.

L. A. CLINTON, *Director.*

PIG FEEDING.

BY C. L. BEACH AND H. L. GARRIGUS.

During the past year ten lots of pigs have been fed the by-products of the dairy. This article gives the daily gains, feed required for 100 pounds of gain and cost of gains. One lot was fed skim milk only, one grain only, four lots milk and grain in the proportion of 1 to 3–4, and four lots in the proportion of 1 to 7–8. The feeding period extended with the different lots from July 19th to April 17th. All lots were fed by the same man and were given all they would consume. When cost of feed is estimated, skim milk is valued at 20 cents per cwt. and grain $20.00 per ton.

EXPERIMENT I.

The first trial was with four lots of three pigs each. These pigs were of the same age and breeding and weighed about 25 pounds each at the beginning of the experiment. Lot 1 was fed skim milk only, lot 4 shorts only, lot 2 one part grain and four of milk, and lot 3 one of grain and eight parts of milk. The feeding period was from July 19th to October 14th, or 86 days.

LOT 1. FED SKIM MILK ONLY.

Three pigs weighing on an average 24.3 pounds at the beginning, gained 62 pounds in 86 days. The average daily gain was 0.72 pound. 2,739 pounds of milk were required for 100 pounds of gain at a cost of $5.48.

LOT 2. FED GRAIN AND SKIM MILK (1 TO 4).

Three pigs weighing on an average 24.5 pounds at the beginning, gained 119 pounds in 86 days. The average daily gain was 1.38 pounds. 935 pounds of skim milk and 233 pounds of grain were required for 100 pounds of gain at a cost of $4.20.

Fig. 9. Lot 1. Pigs fed skim milk only.

Fig. 10. Lot 2. Pigs fed skim milk and grain in proportion of 1 to 3–4.

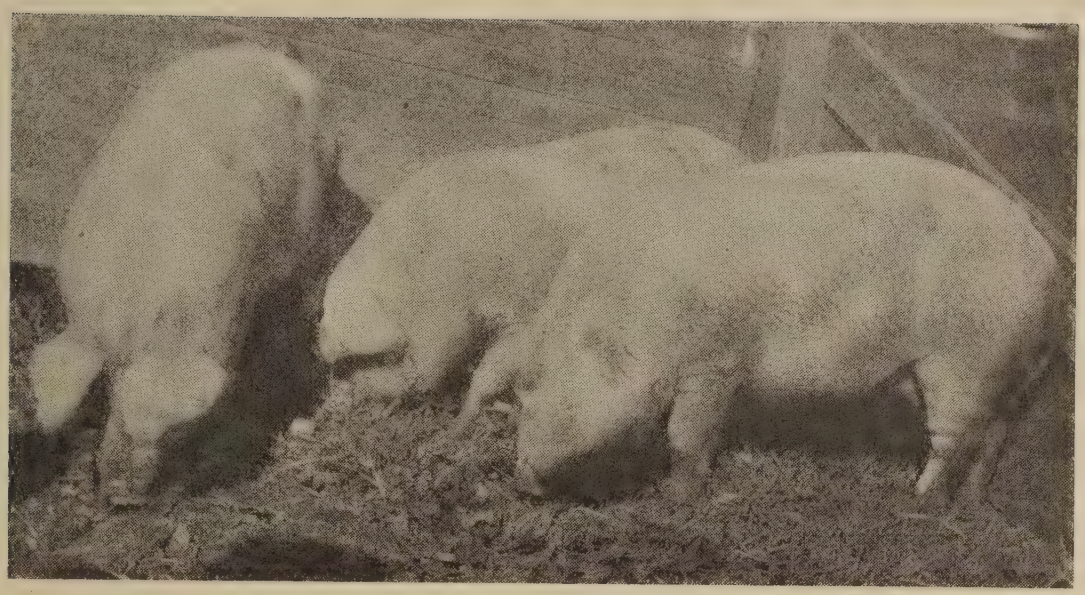


Fig. 11. Lot 3. Pigs fed skim milk and grain in proportion of 1 to 7–8.

Fig. 12. Lot 4. Pigs fed grain only.

LOT 3. FED GRAIN AND SKIM MILK (1 TO 8).

Three pigs weighing on an average 25 pounds at the beginning, gained 110 pounds in 86 days. The average daily gain was 1.28 pounds. The feed required for 100 pounds of gain was 1,341 pounds of skim milk and 168 pounds of grain and cost $4.36.

LOT 4. FED GRAIN ONLY.

Three pigs weighing on an average of 25.3 pounds at the beginning gained 40 pounds in 86 days. The average daily gain was 0.47 pound. The feed required for 100 pounds of gain was 445 pounds and the cost $4.45.

In this trial the largest and most economical gains were made by those lots receiving milk and grain in combination. The least gains were made by the lot receiving grain only. At the arbitrary prices assumed for feed, the lot receiving skim milk only made gains at the greatest cost.

While skim milk is easily digestible, it is too bulky in character. Or, to state it in another way, the capacity of the pig to digest and assimilate is greater than its capacity to consume this watery food. The smaller gains made by the lot receiving shorts only may be attributed to the extra energy required to digest this food.

TABLE 2.

Gains from Grain, Milk, and Grain and Milk.

	No. of Pigs.	Weight at beginning.	Gain. Lbs.	Gain per day. Lbs.	Food for 100 Lbs. gain.		Cost of 100 Lbs. gain.
					Milk. Lbs.	Grain. Lbs.	
Lot 1, - - - - -	3	24.3	62	.72	2739	—	$5.48
Lot 2, - - - - -	3	24.5	119	1.38	935	233	4.20
Lot 3, - - - - -	3	25.0	110	1.28	1341	168	4.36
Lot 4, - - - - -	3	25.3	40	.47	—	445	4.45

On the assumption that 100 pounds of skim milk will contain 8½ pounds of solids and that they are all digestible, and that shorts contain 66 pounds of digestible nutrients, then the amount of digestible nutrients for 100 pounds of gain was lot 1, 232.8; lot 2, 232.2; lot 3, 224.8, and lot 4, 294 pounds.

EXPERIMENTS II. TO V.

In tables 3 and 4 are given the results of four feeding trials. These experiments are not comparable with each other as the feeding was done at different times of the year. The two lots in each experiment, however, were made up of pigs of the same age and breeding. In each experiment the even-numbered lot received grain and milk in the proportion of 1 to 3–4, and the odd-numbered lot in the proportion of 1 to 7–8.

TABLE 3.

Separator Grain and Milk for Pigs. Proportion of Grain to Milk.

	Experiment No.	No. of Pigs.	Weight at beginning. Lbs.	Weight at close. Lbs.	Days fed.	Daily Gain. Proportion of grain to milk. 1:7–8	Daily Gain. Proportion of grain to milk. 1:3–4	Cost of 100 Lbs. Gain. Proportion of grain to milk. 1:3–4	Cost of 100 Lbs. Gain. Proportion of grain to milk. 1:7–8
Lot 2, - -	2	3	24.5	195.0	125	—	1.36	$4.79	—
Lot 3, - -	2	3	25.0	179.0	125	1.23	—	—	$5.12
Lot 5, - -	3	3	58.0	208.0	123	—	1.22	5.60	—
Lot 6, - -	3	3	61.0	196.6	123	1.10	—	—	5.99
Lot 7, - -	4	4	24.0	138.0	96	—	1.19	3.67	—
Lot 8, - -	4	4	24.8	132.0	102	1.05	—	—	4.12
Lot 9, - -	5	4	31.0	173.0	108	—	1.31	3.75	—
Lot 10, -	5	4	27.5	137.0	108	1.01	—	—	4.59
Average, -	—	28	34.5	169.8	114	1.10	1.27	4.45	4.95

TABLE 4.

Separator Skim Milk for 100 lbs. Gain.

	Experiment.	Time of Feeding.	Av. Wgt. at beginning. Lbs.	Gain. Lbs.	Feed for 100 Lbs. Gain. Grain.	Milk.	Water.
Lot 2, - - - - -	2	July 19 to	24.5	170.5	275	1022	81
Lot 3, - - - - -	2	Nov. 21	25.0	154.0	206	1530	125
Lot 5, - - - - -	3	Oct. 14 to	58.0	150.0	363	986	283
Lot 6, - - - - -	3	Feb. 14	61.3	135.3	291	1540	355
Lot 7, - - - - -	4	Dec. 2	24.0	114.0	249	591	287
Lot 8, - - - - -	4	March 8–14	24.8	107.3	204	1042	355
Lot 9, - - - - -	5	Dec. 30 to	31.0	142.0	234	707	177
Lot 10, - - - - -	5	April 17	27.5	109.5	205	1269	190
Average, - - -	—	—	34.5	122.6	253	1086	—

EXPERIMENT II.

In experiment 2 two lots of three pigs were fed from July 19th to November 21st, or a period of 125 days.

LOT 2. FED GRAIN AND SKIM MILK (1 TO 3–4).

Three pigs weighing on an average 24.5 pounds at the beginning made a daily gain of 1.36 pounds each and weighed at the close 195 pounds. The cost of 100 pounds of gain was $4.79.

LOT 3. FED GRAIN AND SKIM MILK (1 TO 7–8).

Three pigs weighing on an average 25 pounds at the beginning made a daily gain of 1.23 pounds each and weighed at the close 179 pounds. The cost of each 100 pounds of gain was $5.12.

EXPERIMENT III.

In this trial two lots of three pigs each were fed from October 14th to February 14th, or a period of 123 days.

LOT 5. FED GRAIN AND SKIM MILK (1 TO 3–4).

Three pigs weighing on an average 58 pounds at the beginning made a daily gain of 1.22 pounds each and weighed at the close 208 pounds. The cost of each 100 pounds of gain was $5.60.

LOT 6. FED GRAIN AND SKIM MILK (1 TO 7–8).

Three pigs weighing on an average 61 pounds at the beginning made a daily gain of 1.10 pounds each and weighed at the close 196.6 pounds. The cost of each 100 pounds of gain was $5.99.

EXPERIMENT IV.

In this trial two lots of four pigs each were fed from December 2d to March 8th for lot 7, and to March 14th for lot 8.

LOT 7. FED GRAIN AND SKIM MILK (1 TO 3–4).

Four pigs weighing on an average 24 pounds at the beginning made a daily gain of 1.19 pounds each and weighed at the close 138 pounds. The cost of each 100 pounds of gain was $3.67.

LOT 8. FED GRAIN AND SKIM MILK (1 TO 7–8).

Four pigs weighing on an average 24.8 pounds at the beginning made a daily gain of 1.05 pounds each and weighed at the close 132 pounds. The cost of each 100 pounds of gain was $4.12.

EXPERIMENT V.

In this trial two lots of four pigs were fed from December 30th to April 17th, or a period of 108 days.

LOT 9. FED GRAIN AND SKIM MILK (1 TO 3–4).

Four pigs weighing on an average at the beginning 31 pounds made a daily gain of 1.31 pounds each and weighed at the close 173 pounds. The cost of each 100 pounds of gain was $3.75.

LOT 10. FED GRAIN AND SKIM MILK (1 TO 7–8).

Four pigs weighing on an average at the beginning 27.5 pounds made a daily gain of 1.01 pounds each and weighed at the close 137 pounds.

RESULTS OF EXPERIMENTS II. TO V.

The average weight of the eight lots of twenty pigs was 34.5 pounds each at the beginning and 169.8 pounds at the close.

The average length of the feeding period was 114 days. The average daily gain of the eight lots of pigs was 1.18 pounds per day and the total gain per pig was 122.6 pounds.

The four lots receiving grain and milk in the proportion of 1 to 7–8 made an average daily gain of 1.10 pounds. The average daily gain of the four lots receiving grain and milk in the proportion of 1 to 3–4 was 1.27 pound.

The cost of 100 pounds of gain for the lot receiving grain and milk in the proportion of 1 to 7–8 was $4.95, and the average for the four lots receiving grain and milk in the proportion 1 to 3–4 was $4.45.

The average amount of food required for 100 pounds of gain was 253 pounds of grain and 1,086 pounds of milk and the average cost was $4.70.

AGE OF PIG AND COST OF GAIN.

In table 5 the results of the feeding trial of each lot of pigs is divided into three periods. The average number of days included in first period is 26, in the second 27, and in the third 54 days.

TABLE 5.

Cost of 100 Lbs. Gain with Pigs at Different Ages.

	Weight at beginning Lbs.	Days Fed.	Gain. Lbs.	Feed for 100 Lb. Gain.		Cost of gain.
				Milk.	Grain.	
First Period.						
Lot 2,	24.5	30	33.8	612	151	$2.73
Lot 3,	25.0	30	33.3	811	112	2.74
Lot 5,	58.6	37	43.6	764	243	3.97
Lot 6,	61.3	37	37.3	1131	189	4.12
Lot 7,	24.0	18	21.9	475	144	2.39
Lot 8,	24.8	18	17.0	644	118	2.57
Lot 9,	31.0	18	14.0	464	261	3.55
Lot 10,	27.5	18	14.0	640	184	3.12
Average,	34.6	26	26.8	699	175	3.15
Second Period.						
Lot 2,	58.3	31	50.3	817	203	3.66
Lot 3,	58.3	31	49.2	1139	137	3.64
Lot 5,	102.2	30	37.3	1252	359	6.04
Lot 6,	98.6	30	27.6	2141	332	7.60
Lot 7,	45.9	18	31.0	522	284	3.88
Lot 8,	41.8	18	31.8	780	198	3.54
Lot 9,	45.0	28	30.2	558	217	3.29
Lot 10,	41.5	28	21.5	1020	185	3.89
Average,	61.4	27	34.8	1029	239	4.45
Third Period.						
Lot 2,	108.6	62	86.4	1298	364	6.23
Lot 3,	107.5	62	71.5	2109	297	7.18
Lot 5,	139.5	45	68.5	975	448	6.43
Lot 6,	126.2	45	70.4	1528	331	6.36
Lot 7,	76.9	50	61.2	667	269	4.02
Lot 8,	73.6	56	58.5	1326	231	4.96
Lot 9,	75.2	57	97.8	788	233	3.90
Lot 10,	63.0	57	74.0	1480	213	5.09
Average,	96.3	54	73.5	1271	298	5.52

FIRST PERIOD.

The average weight of the pigs in the eight lots was 34.6 pounds. In 26 days they gained 26.8 pounds or an average

of 1 pound per day. The feed required for the 100 pounds of gain was 699 pounds of milk and 175 pounds of grain and the cost was $3.15 per hundred pounds.

SECOND PERIOD.

The average weight of the pigs in the eight lots was 61.4 pounds at the beginning. In 27 days the gain was 34.8 pounds, or an average of 1.29 pounds per day. The feed required for the 100 pounds of gain was 1,029 pounds of milk and 239 pounds of grain, and the cost was $4.45 per hundred.

THIRD PERIOD.

The average weight of the pigs in eight lots at the beginning of the third period was 96.3 pounds. In 54 days the gain was 73.5 pounds, or a daily gain of 1.36 pounds. The food required for 100 pounds of gain was 1,271 pounds of milk and 298 pounds of grain, and the cost was $5.52 per hundred pounds.

TABLE 6.

Per Cent. of Dressed to Live Weight.

	No. of Pigs.	Live Weight. Lbs.	Dressed Wgt. Lbs.	Per Cent. of Dressed to Live Weight.
Lot 1,	3	510	394	77.0
Lot 2,	3	585	425	72.7
Lot 3,	3	538	387	72.0
Lot 4,	3	426	315	74.0
Lot 5,	3	623	481	77.2
Lot 6,	2	392	295	75.3
Lot 7,	4	553	409	74.0
Lot 8,	4	527	398	75.5
Lot 9,	4	691	535	77.4
Lot 10,	2	317	232	73.2
Average,	31	166.5	124.9	75.

LIVE AND DRESSED WEIGHT.

Table 6. The average unfasted live weight of 31 pigs was 166.5 pounds. The dressed weight was 124.9 pounds and the proportion of dressed to live weight was 75 per cent.

CREAMERY PROBLEMS.

BY C. L. BEACH.

THE HAND SEPARATOR.

The creamery system of Connecticut is conducted almost without exception on the cream gathering method. The Cooley system of raising cream is still used by the larger number of dairymen, but the centrifugal method is rapidly gaining ground. The following table shows the number of separators and Cooley creamers used by the patrons of eighteen creameries, as reported in 1903. Out of a total of 1362 patrons, 256, or 19 per cent., were using separators.

TABLE 7.

Number of Separators and Cooley Creamers in use by patrons of eighteen Creameries in Connecticut.

No. of Creamery.	Total No. of Patrons.	No. of Patrons using Separators.	No. of Patrons using Cooley Creamers.
1,	92	10	82
2,	75	15	60
3,	13	0	13
4,	79	23	56
5,	39	16	23
6,	60	5	55
7,	80	15	65
8,	41	16	25
9,	90	32	58
10,	88	9	79
11,	74	46	28
12,	102	12	90
13,	36	1	35
14,	62	13	49
15,	85	8	77
16,	208	19	189
17,	48	16	32
18,	90	0	90
Total,	1362	256	1106

One of the advantages of the separator over the Cooley creamer is in the more complete removal of the butter fat from the milk. Table 8 gives the Babcock tests of thirteen samples of skim milk from Cooley creamers and thirty-six samples of skim milk from hand separators. These samples were taken at the farm by the dairymen and forwarded to the Station by mail. Instructions were given to thoroughly mix the skim milk of one skimming before taking the sample. The tests were made by the Babcock method in the usual way, and the readings were taken from the double neck Wagner skim milk test bottles.

TABLE 8.

Per Cent. of Fat in Skim Milk from Hand Separators and Cooley Creamers.

Cooley Creamer.	De Laval Separator.	U. S. Separator.	National Separator.	Empire Separator.	Sharples Tubular Separator.
%	%	%	%	%	%
.09	.05	.04	.03	.04	.02
1.10	.01	.05	.07	.06	.08
.22	.03	.07	.05	.06	—
.20	.01	.15	.12	.08	—
.12	.03	.11	.04	—	—
.16	.01	.03	.15	—	—
.18	.05	.03	—	—	—
.26	.04	.02	—	—	—
.12	.01	.05	—	—	—
.21	.05	.12	—	—	—
.16	.06	.04	—	—	—
.39	.02	—	—	—	—
.30	.13	—	—	—	—
Avg. .27	.038	.064	.076	.06	.05

Average of 13 samples of Cooley skim milk, 0.27%.
Average of 36 samples of separator skim milk, 0.056%.

These results are no doubt too low. There is a small amount of "residual fat" in all milks, not recovered by the usual Babcock method. In full milk samples this error is compensated for by the method of reading the tests. In skim milk tests an addition of about one-tenth per cent. to the reading would give results more nearly agreeing with the gravimetric analysis. Even with this addition the results show a remarkably efficient skimming by the hand separator in the hands of

the ordinary operator. Taking the tests as read, however, the thirteen samples of Cooley Creamer skim milk averaged 0.27 per cent. fat, and the thirty-six samples of separator skim milk averaged 0.056 per cent. fat. The Cooley cream tested 18.3 per cent. fat, and the separator cream 23.1 per cent. fat. The average number of cows in the herd when separators were used was ten.

TABLE 9.

Comparison of Hand Separator and Cooley Creamer. Loss of Fat in Skim Milk for One Year when Cows average 5,000 Pounds of Milk Each.

No. of Cows.	Lbs. of Skim Milk.	Test of Skim Milk. %	Lbs. of fat in Skim Milk.	Value of fat at 28c. per lb.
Cooley Creamer—				
5,	20,425	.27	55.14	$15.44
10,	40,850	.27	110.29	30.88
20,	81,100	.27	220.59	61.76
40,	163,400	.27	441.18	123.53
Hand Separator—				
5,	17,225	.056	9.65	$2.70
10,	34,450	.056	19.30	5.40
20,	68,900	.056	38.58	10.80
40,	137,800	.056	77.17	21.61

On the basis of the above calculation, the hand separator, compared with the Cooley Creamer, effects a saving of $25.48 in one year with a herd of ten cows; $50.96 with a herd of twenty cows; and $101.92 with a herd of forty cows.

One of the most important factors in the selection of a separator is a consideration of the capacity of the machine. Styles of separators ranging in capacity from 300 to 1,200 pounds per hour may be purchased at from $70.00 to $200.00. With a herd of 20 cows, yielding 5,000 pounds each, the time required to separate the milk would vary from 333 hours with the smaller machine, to 83 hours with the larger. At 15 cents per hour the cost would vary from $49.95 to $12.45.

The separator making the most favorable showing in Table 8 would effect a saving over the style of separator making the least favorable showing of .038 per cent. of fat. With a herd

TABLE 10.

Labor Cost of Separating with Hand Separator the Milk Yielded by Twenty Cows for One Year.

STYLE OF SEPARATOR.	Lbs. Capacity per hour.	Cost of Separator.	Hours required to separate milk in one year.	Cost of labor for one year to operate separator.
A, - - - - - - - -	300	$70.00	333	$49.95
B, - - - - - - - -	400	85.00	250	37.50
C, - - - - - - - -	500	100.00	200	30.00
D, - - - - - - - -	700	125.00	143	21.45
E, - - - - - - - -	1200	200.00	83	12.43

of 20 cows this saving in one year would amount to $7.95 when butter fat is valued at 28 cents per pound. The saving effected by reason of the capacity of the separator (Table 10) would amount to $37.52.

TESTING SKIM MILK SAMPLES.

In the ordinary operation of the Babcock milk tester a small amount of fat is not brought into the neck of the bottle. This slight loss of the smallest fat globules is compensated for in the testing of whole milk by reading from the bottom to the extreme top of the fat column. When readings of whole milk tests are made in this way, the results of the Babcock tester agree with gravimetric analyses.

In testing skim milk the same amount of residual fat is not recovered, and the reading of tests of skim milk or butter milk are usually too low. It has been suggested that in testing skim milk an excess of acid be used and that the samples be run at full speed for six minutes.

In Table 11 are given the average results of duplicate analyses of ten samples of skim milk and the average of duplicate Babcock tests of the same sample. The readings were from the Wagner double neck bottle graduated to hundredths of one per cent. The average gravimetric analyses of the ten samples was fourteen-hundredths of one per cent. The average of the same samples with the Babcock test, when 17.6 cc. of acid was used, was four-hundredths per cent. When 25 cc. was used the Babcock readings were six-hundredths per cent.

TABLE 11.

A Comparison of the Gravimetric Analyses and of Babcock Tests of Skim Milk.

Sample Number.	Per Cent. of Fat.		
	Gravimetric Analyses.	Steam Turbine Tests.	
		17.6 cc. Acid.	25 cc. Acid.
No. 1, - - - - - - -	.141	.045	.060
No. 2, - - - - - - -	.143	.055	.055
No. 3, - - - - - - -	.149	.015	.030
No. 4, - - - - - - -	.122	.025	.055
No. 5, - - - - - - -	.121	.080	.080
No. 6, - - - - - - -	.118	.060	.090
No. 7, - - - - - - -	.147	.055	.085
No. 8, - - - - - - -	.213	.065	.090
No. 9, - - - - - - -	.135	.020	.035
No. 10, - - - - - - -	.158	.040	.050
Average, - - - - - -	.144	.046	.063

These results show that even when an excess of acid was used the Babcock readings were lower than gravimetric analyses.

In the testing of samples of skim milk, it has been recommended to whirl the bottles in a steam-heated tester in which the temperature rises to nearly 200° F. The excess of acid, the long whirling, and the high temperature all aid in the separation of the last trace of fat.

The Wisconsin Station Report (1903) gives a comparison of results of gravimetric analyses and of Babcock tests of skim milk. The average gravimetric analyses of ten samples of skim milk was 0.077 per cent. of fat. With the Babcock method, when an excess of acid was used and the tests run for six minutes at a temperature of 200° F., the results were 0.056 per cent., and at a temperature of 140°, 0.03 per cent. fat.

ERRORS IN READING BABCOCK TESTS.

The readings of Babcock tests should be made at a temperature of 140° F. In turbine testers that prevent the free escape of steam, milk samples may come .2 or .3 per cent. too high, and cream samples as much as 1 per cent. too high in some cases. The effect of differences in temperature of the fat on

the readings obtained is illustrated in the following table. Ten samples of cream were tested in duplicate, and the readings made at a temperature of 130° with the average result of 20.94 per cent. At a temperature of 180° F. the readings were 21.36 per cent., or .42 per cent. higher.

TABLE 12.

Comparative Readings of Cream Tests at different Temperatures.

No. of Sample.	Reading at Temperature of 130°.	Reading at Temperature of 180°.	Difference in Reading.
	%	%	%
No. 1,	22.80	23.25	.45
No. 2,	18.80	19.25	.45
No. 3,	17.00	17.37	.37
No. 4,	19.08	19.50	.42
No. 5.	15.00	15.25	.25
No. 6,	26.70	27.25	.55
No. 7,	26.50	27.00	.50
No. 8,	23.00	23.50	.50
No. 9,	22.25	22.75	.50
No. 10,	18.25	18.50	.25
Average,	20.94	21.36	.42

The coefficient of expansion for butter fat is .000355 for each degree F. (122° to 212°). The amount of fat representing 5 per cent. occupies a volume of 1 cc. The theoretical difference in the volume of fat at two temperatures may be calculated as follows: coefficient of expansion × cc. of fat × difference of degrees of temperature. In the case of 21 per cent. cream the volume of fat at 190° would be .07455 cc. (.000355 × 21⁄5 × 50) greater than at 140°. Since 1 cc. of fat represents 5 per cent., the reading at 190° would be .07455 × 5=.37275 per cent. too high.

ERROR IN MEASURING CREAM FOR BABCOCK TEST.

The usual method of taking a sample of cream for the Babcock test is to measure out 18 cc. Cream may contain from 12 to 60 per cent. of fat. The more fat cream contains, the less its specific gravity and the less a given volume will weigh.

Rich cream is also more viscous, and when measured with a pipette less will be delivered. The error from measuring cream for the Babcock test is considerable, as is illustrated in the following table. Patrons of creameries, especially those delivering separator cream, should insist that the sample for Babcock testing be weighed.

In this table the third column gives the weight of 18 cc. of cream. The fourth column gives the average reading of the duplicate tests. The fifth column gives the corrected reading for 18 grams. The last column shows the error that may result from measuring samples.

TABLE 13.

Error in Measuring Cream for Babcock Test.

No. of Sample.	Volume Taken.	Weight of 18 cc.	Babcock Test. Fat.	Correct Reading. Fat.	Error in Measuring.
	cc.	Grams.	%	%	%
No. 1, - - - -	18	18.332	15.25	14.97	+ .28
No. 2, - - - -	18	18.205	19.12	18.90	+ .22
No. 3, - - - -	18	18.077	23.00	22.89	+ .11
No. 4, - - - -	18	17.962	27.65	27.72	— .07
No. 5, - - - -	18	17.892	31.50	31.70	— .20
No. 6, - - - -	18	17.779	37.12	37.58	— .46
No. 7, - - - -	18	17.497	41.88	43.07	—1.19
No. 8, - - - -	18	17.375	45.88	47.54	—1.66
No. 9, - - - -	18	17.214	49.38	51.66	—2.28
No. 10, - - - -	18	17.087	54.12	57.00	—2.88
No. 11, - - - -	18	16.554	58.37	63.49	—5.12

PURE CULTURES IN BUTTER MAKING.

The use of pure cultures in cream ripening is coming into more common practice with our best butter makers. There is no doubt that there is an advantage in these cultures, especially where it is difficult to secure good material from which to make a "home-made starter." The advantage of a pure culture over a home-made starter will be more apparent, therefore, in a creamery than in a private dairy, and in the gathered cream system than in the separator creamery.

During the past year our butter maker, Mr. D. D. Kinne, divided fourteen lots of cream into two equal portions, and

ripened one with a skim milk starter and the other with a starter made from a pure culture. Otherwise both lots of cream were treated alike. Samples of butter were sent to Boston and scored by Mr. Orrin Douglas. Beginning with numbers 1 and 2, the odd numbered churnings were ripened with skim milk starters, and the even numbered churnings with pure culture starters.

TABLE 14.

Scores of Butter made from Cream ripened with Skim Milk and Pure Culture Starters.

DATE.	No. of Churning.	KIND OF STARTER.			
		Skim Milk.	Parke-Davis.	Douglas.	B 41.
March 4,	1	95.0	—	—	—
	2	—	94.0	—	—
March 11,	3	93.0	—	—	—
	4	—	93.5	—	—
March 20,	9	93.0	—	—	—
	10	—	90.0	—	—
March 24,	11	94.0	—	—	—
	12	—	93.5	—	—
March 27,	13	93.5	—	—	—
	14	—	93.0	—	—
March 31,	15	94.5	—	—	—
	16	—	94.5	—	—
April 3,	17	95.0	—	—	—
	18	—	95.0	—	—
April 7,	19	95.5	—	—	—
	20	—	—	94.5	—
April 10,	21	93.5	—	—	—
	22	—	—	94.0	—
April 14,	23	94.5	—	—	—
	24	—	—	95.0	—
April 17,	25	94.0	—	—	—
	26	—	—	96.0	—
April 21,	27	93.5	—	—	—
	28	—	—	93.5	—
April 24,	29	94.0	—	—	—
	30	—	—	—	95
April 28,	31	94.0	—	—	—
	32	—	—	—	95
	—	94.1	93.3	94.6	95

The average score of the butter from fourteen churnings ripened with skim milk starters was 94.1 on the scale of 100

for perfect. The average score of the butter from the fourteen churnings ripened with pure culture starters was 94.0. In attempting to interpret these results, it should be borne in mind that the skim milk starters were made from selected milk.

TABLE 15.

Bacterial Content of Starter, Cream and Butter.

Number of Churnings.	Starter. Bacteria per cc.			Cream at time of Churning. Bacteria per cc.			Butter. Bacteria per Gram.			Scores. Avg. of 2	
	Total Number.	Per Cent. of Acids.	Per Cent. of Liquefiers.	Total Number.	Per Cent. of Acids.	Per Cent. of Liquefiers.	Total Number.	Per Cent. of Acids.	Per Cent. of Liquefiers.	3 to 4 Days after Churning.	2 Weeks after Churning.
2, -	1,037,000,000	100.0	.008	773,541,660	98.6	.03	16,000,000	92.2	2.3	96½	96
1, -	1,208,333,000	100.0	.00	604,791,667	99.9	.05	15,333,300	97.9	2.1	96¼	96
4, -	1,244,083,333	100.0	.00	816,250,000	100.0	.00	9,625,000	95.2	.0	97½	95¼
3, -	1,372,500,000	100.0	.006	—	—	.00	11,333,333	96.3	.4	96¾	96½
6, -	1,422,916,666	86.0	.003	747,083,000	99.9	.02	18,250,000	91.0	.0	96½	96
5, -	1,682,500,000	100.0	.00	939,583,333	99.9	.03	38,050,000	85.0	.13	96¾	97¼
8, -	1,579,166,000	100.0	.00	694,583,000	99.9	.05	32,208,000	99.8	.0	96½	—
7, -	1,263,333,000	99.9	.00	727,083,000	99.9	.07	30,979,000	96.5	.5	95½	—
9, -	1,114,000,000	99.9	.09	561,250,000	99.9	.05	19,458,000	97.7	.0	96½	—
10, -	1,341,666,000	100.0	.00	661,250,000	99.9	.01	15,729,000	95.4	.3	96⅛	—
11, -	1,107,916,000	100.0	.00	810,410,000	99.9	.07	38,937,500	99.8	.0	97¼	—
12, -	1,207,083,000	99.9	.00	940,000,000	99.9	.07	26,020,833	95.8	.0	96¼	—

In Table 15 is recorded the bacterial content of twelve samples of butter, of the cream from which the butter was made, and of the starter used in ripening the cream. In these trials the bacteriological work was done by Professor W. A. Stocking, Jr., and the butter was made by D. W. Roberts. The work was undertaken to test the value of various pure cultures in cream ripening.

The number of bacteria in the starters used was found to be over a billion. With one exception the starter contained over 99 per cent. of acid organisms, and in all cases less than .1 per cent. of liquefying bacteria.

The cream contained from five million to nine million of bacteria per cc. The number of liquefying bacteria was less than .1 per cent., and with one exception the number of acid organisms was more than 99 per cent.

The butter contained from nine million to thirty-eight million of bacteria per gram. With two exceptions the number of acid organisms in the butter was over 90 per cent. In two samples the number of liquefying bacteria was not more than .5 of one per cent. The scores of the butter were high and very uniform.

Churnings 1, 3, and 5 were made from cream ripened with the Douglas culture; 2, 4, and 6 from B 41; 7, 9, and 11 from the Douglas culture; and 8, 10, and 12 from the Douglas special. In these trials the starters were ripened to about .8 per cent. of acidity, and the cream to .6 per cent. of acidity. The ripening temperature of the cream was 70°, the churning temperature 55°, and the cream tested 28 per cent. fat.

SPRAYING NOTES FOR 1904–1905.

BY E. R. BENNETT.

Bordeaux mixture as a remedy for late blight of potatoes has been used for several years with varying degrees of success.

During the seasons of 1903, 1904, and 1905, the potato fields at the Connecticut Agricultural College were sprayed with Bordeaux mixture, the work being done with an automatic horse-power spray cart. The results from this work, like those obtained at many other places, were not all that could be desired. An increase in yield per acre was obtained, but rotting of the tubers was not prevented.

In the spring of 1904 an experiment was started at the Storrs Agricultural Experiment Station to deterime if late blight and the consequent rotting of the tubers could be prevented by application of Bordeaux mixture.

A plot of ground was planted May 11 with Green Mountain potatoes. Cultivation was begun as soon as the plants were up and was continued until the vines covered the ground. Applications of Bordeaux mixture were made on three of the six equal rows on the following dates:—June 1, 11, 18, July 2, 9, 13, 25, 30, August 6, 19, and 30. July 2 and July 13 Paris green was added to the Bordeaux mixture. The check rows were sprayed four times with Paris green.

RESULTS.

Until August 30 little difference could be noticed between the sprayed and the unsprayed rows, with the exception that the work of the striped beetle and black flea beetle were much more in evidence on the unsprayed than on the sprayed vines. At this time the unsprayed plot began to have an appearance of ripening. Investigation showed the presence of early blight. September 13 both early and late blight were found on the plants, and the leaves were practically dead on the whole un-

sprayed plot. At the time of the first killing frost, September 21, the unsprayed plants were all dead and to all appearances had ripened naturally. The sprayed plants were green, growing well, and would probably have increased for a week or more had the frost held off.

FIG. 13. Potato plots; sprayed at right, unsprayed at left.

Both sprayed and unsprayed plots were dug October 3. The yields were as follows:

Sprayed plot, 14 bushels, large.
Sprayed plot, 1½ bushels, small (none rotten).
Unsprayed plot, 7¼ bushels, large.
Unsprayed plot, 1½ bushels, small,
A few too badly decayed to handle.
Yield per acre, sprayed, large, 337
Yield per acre, sprayed, total, 376
Yield per acre, unsprayed, large, 180
Yield per acre, unsprayed, total, 217

At the time of digging many potatoes from the unsprayed plot had irregular purple or brownish spots on their surfaces. When cut into these spots showed discoloration extending into the tissue of the potato about one-quarter of an inch.

Microscopical examination showed these spots to be the early stages of rot, caused by late blight. The potatoes from both plots were put in crates, labeled, and placed in a cool room to await developments.

November 1 the potatoes from both plots were carefully examined and counted. The colored spots on the surfaces of the potatoes had in most cases developed into a dry, black rot. Although at time of digging no rot spots were noticeable on potatoes from the sprayed plot, 2.5 per cent. of them now showed more or less of the dry rot. Of those from the unsprayed plot, 26 per cent. were badly decayed.

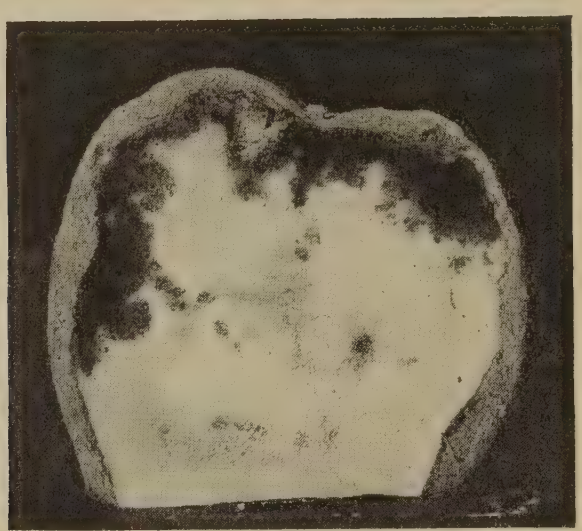


FIG. 14. Section of potato decayed by late blight.

The results of spraying potatoes with Bordeaux in 1904 gave evidence that blight can be controlled. In the spring of 1905 the experiment was continued. Twenty-nine rows of Green Mountain potatoes were planted May 13. This area was divided into four plots of six rows each with check rows for each side and between the plots.

One object of the experiment was to ascertain the least number of applications of Bordeaux that would be necessary to prevent loss from blight. The following table gives the number and dates of applications to each plot and the yield of potatoes:

TABLE 16.

Application of Bordeaux and Paris Green, and the Yield per Plot and per Acre.

No. of Plot.	Date of Application of Bordeaux and Paris Green, 1905.								Yield.			
	July.				August.			September.	Per Plot.		Per Acre	
	7th.	15th.	22d.	29th.	7th.	14th.	22d.	6th.	Bu. L.	Bu. S.	Bu. L.	Bu. S.
1	Paris Green.	Paris Green.	Bugged.	—	—	Paris Green.	—	—	1⅛	1	22½	20
2	Paris Green.	Paris Green.	Bordeaux and Paris Green.	—	Bordeaux.	—	—	—	7½	1½	150	30
3	Bordeaux and Paris Green.	Paris Green.	Bordeaux and Paris Green.	—	Bordeaux.	—	Bordeaux.	Bordeaux.	12½	1	250	20
4	Bordeaux and Paris Green.	Bordeaux and Paris Green.	Bordeaux and Paris Green.	Bordeaux.	Bordeaux.	Bordeaux.	Bordeaux.	Bordeaux.	16	1¼	320	25

Several conditions and causes are responsible for the great difference in yield between the different plots. The potato beetles became numerous and were working badly on all the plots when the first application of Paris green was made, July 7. Where the Bordeaux and Paris green were used together, the beetles disappeared in a day or two. Where the Paris green was used alone, but few of the beetles were killed. By the time it was evident that the poison alone was not going to destroy the beetles, much of the foliage from plots 1 and 2 had been damaged quite seriously. As soon as the weather would permit, a second application of Paris green was given, the poison being used this time, at the rate of 1 pound of Paris green to 80 gallons of water. Even this did not destroy all the beetles, so the old fashioned way of "bugging" with a pan and stick was resorted to at the same time that the third application of Bordeaux was given to plot 4. Plot 1 was so badly damaged that it never fully recovered its foliage. Plot 2 recovered its foliage and kept green till within about two weeks of the time when plot 4's foliage died. The black flea beetle worked badly on the unsprayed potatoes at different times through the season. Fungi did not show seriously on any of the foliage, but early blight was present, and probably more or less late blight, though neither worked rapidly enough to cause noticeable damage. None of the potatoes showed signs of blight rot when dug, nor afterwards in the cellar.

CAN DISCOLORED POTATOES BE PREVENTED FROM ROTTING AFTER DIGGING?

A quantity of potatoes from the 1904 crop that showed discolored spots but that were not spoiled for immediate use were taken from the field at the time of digging, washed, and placed in crates for treatment to determine whether they could be prevented from rotting. Part of these were thoroughly sprinkled with dry, air-slacked lime, and part of them were left untreated.

On January 11 these potatoes were examined. The discolored spots on both the treated and untreated were sunken and black, and the diseased areas were considerably enlarged. No soft rot had appeared, and nearly every potato had one or more apparently healthy sprouted eyes. It is hardly probable that

the potatoes which show when dug discolored spots caused by the blight can be prevented from rotting, since the mycelium of the fungus is already in the tissue of the potato.

Decaying potatoes from different parts of Connecticut, from Maine, Vermont, and New York were examined under the microscope, and all were found to contain the mycelium of the blight. The rot of some of these was dry and black; of others, soft, light-colored, and stringy. Most authorities agree that Phytophera alone does not cause soft rot in potatoes. Frequently, however, we find bacteria working with the blight, that cause a rapid breaking down of the tissues of the potato and consequently a soft rot.

This naturally brings up the question, When should potatoes be dug if they are found to be rotting in the ground from late blight? The spores of late blight are supposed to be carried down to the tuber in the ground by rains or by insects. When they reach the tuber they send out a mycelial thread that enters the tuber and by developing causes the rot. It is a well known fact that these spores retain their vitality but a short time. Therefore, those potatoes that do not become infected within a short time after the vines die will not rot, and those that are infected will rot whether they are dug or not. Observation has shown that rot does not spread from one potato to another in the ground. We should advise that potatoes that are rotting in the ground from blight be left as long as the season will permit before digging.

Observations of the conditions in the field the past two summers have led to the conclusion that the increase in yield of potatoes from spraying is not all due to the control of late blight. Anything that reduces the leaf surface of the plants must tend to reduce the yield of tubers. Flea beetles and early blight were both quite prevalent last season on unsprayed potatoes but were not troublesome on the sprayed vines. Flea beetles perforate the surface of the leaves, not only reducing the leaf surface but giving fungous diseases a means of entrance to the plant.

Bordeaux mixture is not poisonous to insects, but their distaste for it is such that most of them leave the sprayed plants and go to the unsprayed ones or to other vegetation. This was very noticeable during the summer of 1904, when the flea

beetles were very numerous on potatoes, tomatoes, and many other plants. Paris green had no apparent effect on these insects, but all plants sprayed with Bordeaux mixture were troubled much less by them than were those unsprayed.

Early blight does its share of damage to potato plants. This fungus does not cause rotting of tubers, but cuts down the yield by destroying the leaf tissues of the plant.

WHEN TO SPRAY.

When to spray, then, depends upon what we spray for. Some good results have been obtained from two applications of Bordeaux mixture. These were made in August and September, just as the late blight began to make its appearance.

If striped potato beetles are numerous, spraying with poison must be done early in the season. The attacks of the first brood of flea beetles are likely to occur at the same time, and, as in the case of the striped beetle, their work continues throughout the season.

Early blight comes in July and may do considerable damage to the foliage before there is danger of late blight. Arsenites applied with Bordeaux mixture are more effectual and less dangerous than when applied alone. The work of applying Bordeaux and arsenites is not much greater than when poison is used alone; therefore we recommend that Bordeaux mixture be used early in the season, particularly if it is necessary to use arsenites for potato beetle.

Whether early spraying is done or not, applications for late blight should be begun about the first of August, and should be followed at intervals of two to three weeks until vines are ripe or killed with frost.

THOROUGHNESS OF WORK NECESSARY FOR SUCCESS.

We believe that thoroughness of work is more important than the number of applications. It must be borne in mind that Bordeaux spraying is a *preventive* rather than a *cure*. Nine-tenths of the surface of a leaf may be covered with Bordeaux, but if the spores of the fungus fall and develop on the one-tenth of exposed surface, the whole leaf may be killed by the blight.

To do thorough work and not waste material a fine spray must be obtained, and each plant must be treated long enough to cover its whole surface.

MACHINERY FOR SPRAYING POTATOES.

Early in the season, while the plants are small, almost any apparatus will do the work satisfactorily. The automatic horse power sprayers save time, but to produce sufficient power the machine must be driven so rapidly across the field that the plants are never more than partially covered with the mixture.

Fig. 15.—Spraying potato plots.

A better apparatus for spraying while the plants are small would be one that would spray several rows as the apparatus is driven slowly along, the pressure being furnished by steam or gas power. After the plants become large, automatic machinery cannot do perfect work. A good pump or power machine mounted on a wagon, with two lines of hose so that the nozzles may be directed at all sides of the plants, will do satisfactory work.

TOMATO SPRAYING EXPERIMENTS.

The fact that the tomato crop is reduced every year by fungi and insects is not generally appreciated. The tomato plant was originally a perennial. Now most varieties are usually dead or

show signs of "ripening off" long before frost comes in the fall. All tomato plants, whether early or late, would continue growth for a longer period than our season permits, if the life of the plant were not reduced by parasitic diseases.

In order to test this theory, a plot of tomatoes was set about May 25, 1904. The variety used was Earliana. The plot consisted of six equal rows. Two of them were kept pruned to one stem and tied to stakes. The next two rows were sup-

Fig. 16.—Sprayed and unsprayed tomatoes.

ported by stakes and wire trellises, while the other two rows were left to grow unsupported. All plants were given the same fertilization and cultivation. Bordeaux was applied on the following dates: June 1, 11, 18; July 2, 13, 25, 30; August 6, 29.

On August 5 the foliage of the unsprayed plants was badly spotted with tomato-leaf blight (Septoria licopersica). By August 20 the unsprayed plants had lost practically all their leaves from this disease. When frost came, September 21, the unsprayed vines were dead and dry, but the sprayed vines were still green. Unfortunately, the data of weights of tomatoes from the respective rows were not kept accurately enough to be of value. The difference in yield was not so great between the sprayed and unsprayed plants as was the difference in quality. At first the quality of all the fruits was the same. When the leaves of the unsprayed plants became diseased, the fruits on them ripened just the same as those on the sprayed plants,

but while the texture of the fruits on the sprayed plants remained the same as at first, those on the unsprayed plants became soft and watery and of poor quality.

This experiment was repeated in detail during the season of 1905, with the exception that the variety used was Jewel instead of Earliana. Plants were set June 3. Bordeaux was applied on July 22, 29; August 7, 14, 22.

The following table gives dates of picking and the yield of ripe and green fruits in pounds:

TABLE 17.

Date of Picking.	Trimmed to 1 Stem and tied to Stakes.		Supported on Wire Trellises		Unsupported.	
	Unsprayed.	Sprayed.	Unsprayed.	Sprayed.	Unsprayed.	Sprayed.
August 15,	0	¼	½	½	0	0
August 30,	2¼	½	1	½	½	½
September 5,	½	3¼	0	0	¼	1
September 7,	1	1½	½	½	2	1
September 15,	7	7	7½	6	4½	10
September 18,	4	7¼	11	9½	14½	15½
September 21,	3	3¼	5¼	5½	5¼	6
September 24,	2¼	8¾	5¾	8¼	7¾	12½
September 30,	0	4	3	8½	2½	7
October 4,	¾	¾	2	6½	1¾	3¾
October 7,	½	1	½	4	2	6¾
October 12,	0	0	0	4½	1	2
Total ripe,	21¼	37½	37	54¼	42	66
Green, October 12,	4¼	10	33½	63	12½	47½
Total,	25½	47½	70½	117¼	54½	113½

At the time of first picking the lower leaves of the unsprayed plants were beginning to turn yellow and die. October 1 the foliage of the unsprayed vines was gone, except a little tuft at the end of each stem.

As with the experiment of the previous year, the difference in quality between the fruit from the sprayed and unsprayed plants was very marked. Soon after the first picking the unsprayed vines set no more fruits, though the ones already set ripened off as rapidly as those on the sprayed plants.

The general health and the firm character of the fruits from the sprayed vines was noticeable at each picking; for these fruits were firmly attached to the vines, while those from the unsprayed vines were loosely attached or had fallen before ready to pick. This was still more noticeable at the last picking, when all green fruits as well as the ripe were picked. Many of the green fruits of the unsprayed rows had fallen from the vines or were loosely attached and more or less soft, while those from the sprayed rows were so firmly attached that they were picked with difficulty.

All varieties of tomatoes are not equally subject to disease. Of sixty-seven varieties of tomatoes on the College trial plot, some were defoliated, while some were but slightly diseased. The large, potato-leaved varieties seem to be less subject to this disease than the smaller, finer-leaved, and earlier varieties.

DISEASES OF TOMATOES.

The disease that caused the decrease of yield of the unsprayed plants in these two experiments was the leaf blight (Septoria licopersica). It is first noticeable as small, black or brown spots on the leaves and stems of the plants, occurring first on the lower and older leaves; but with favorable weather it spreads rapidly till the plant is defoliated and the spots on the stems have coalesced into irregular, blackish patches. If a piece of bark with these spots be examined under a high power microscope, innumerable small, crescent-shaped bodies may be seen. These are the fruiting spores of the fungus.

Another disease that did some damage to the fruits was the black rot (Macrosporium tomato). This disease attacks the blossom end of the fruits, usually before ripening. Spraying did not entirely prevent this disease, nor was it less prevalent on the fruits of plants tied to stakes than on those lying on the ground.

CULTURAL METHODS.

Little comment need be made on the different systems of growing tomatoes in these two experiments. A glance at Table 17 will show that the total yield of tomatoes on either the sprayed or unsprayed vines of those trimmed to one stem and tied to stakes was only about one-half as much as from those on

FIG. 17. Leaf blight of tomatoes.

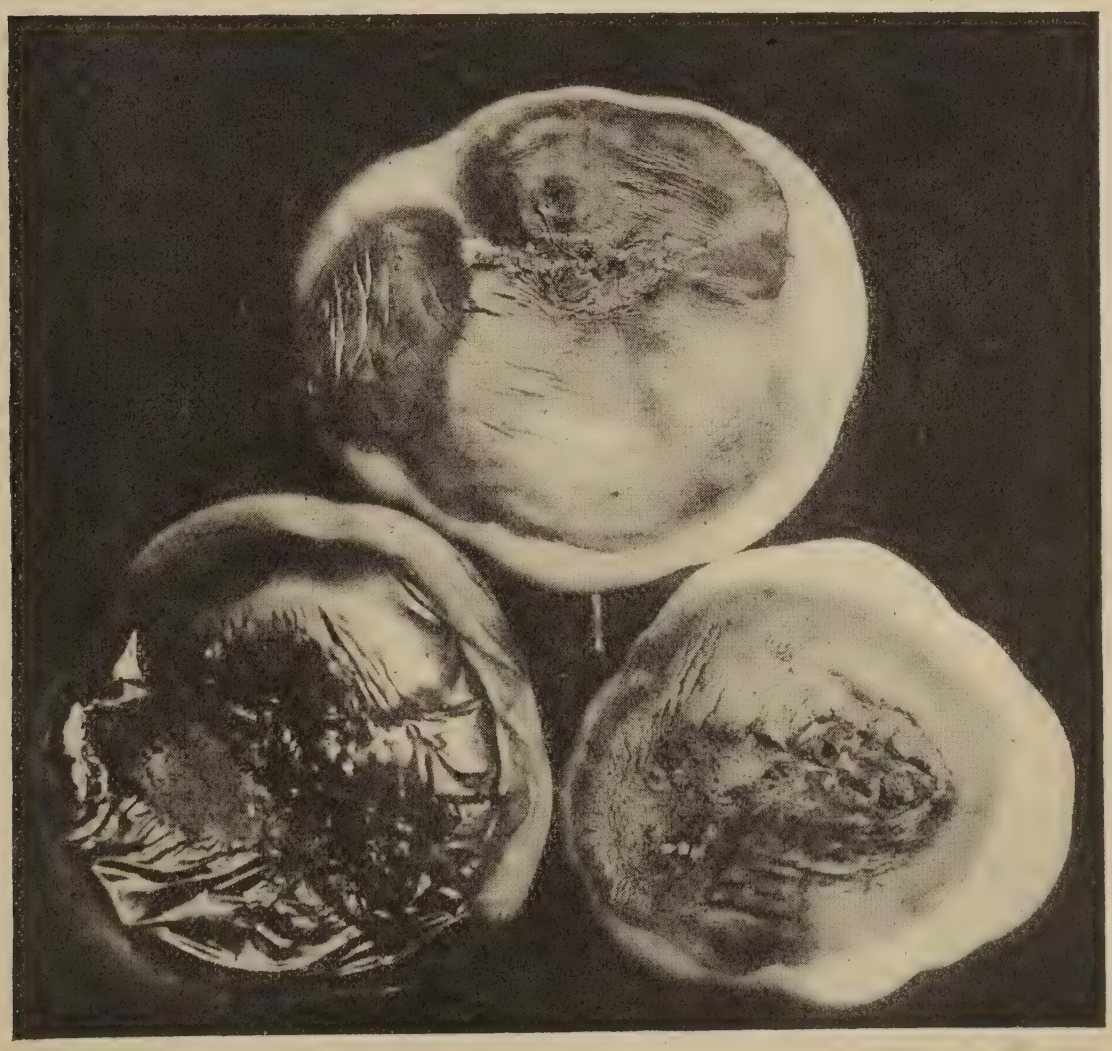


FIG. 18. Black rot of tomatoes.

trellises or untrimmed. No advantage was gained either in early ripening or quality of fruit. Apparently the only advantage of this system is that plants can be set much more closely together without crowding. In any case the work of pruning and tying the plants to stakes would make this system too expensive for anything but a small garden.

Bulletin No. 30 of this Station gives the results of some work done during the summer of 1902 on spraying cucumbers and melons to prevent melon blight. This experiment was repeated during the years 1904 and 1905.

June 10, 1904, a plot consisting of four equal rows of long green cucumbers was planted. Applications of Bordeaux were given on June 18, July 2, 13, 25, 30, August 6, and 19.

Table 18 gives the dates of picking and the number of cucumbers from sprayed and unsprayed plots.

TABLE 18.

	Sprayed.	Unsprayed.
July 30,	10	30
August 1,	54	119
August 3,	51	110
August 5,	84	176
August 9,	209	414
August 11,	164	221
August 13,	155	230
August 16,	228	511
August 22,	384	645
August 24,	297	318
August 26,	493	576
August 29,	822	951
September 1,	617	1002
September 5,	525	764
September 8,	360	512
September 10,	326	478
September 12,	568	747
	5336	7786

All cucurbits were particularly productive in 1904, and no disease developed in them. From the first spraying a difference could be seen in favor of the unsprayed plants. The Bordeaux caused a thickening of the tissue of the leaves and retarded the growth of the plants, though it did not kill any of the leaves. This deleterious effect of Bordeaux spraying was not noticed in the work of the previous year, but was very noticeable on all cucurbits during 1904 and to some extent in 1905. The work along this line in 1905 gave similar results to that of 1903.

A similar although somewhat smaller plot of the same variety of cucumbers was again planted July 3, 1905. Spray was applied to one-half on July 29, August 14, 22, 30, September 5. The yield of the plots was as follows:—

TABLE 19.

	Sprayed	Unsprayed
August 23,	61	40
August 25,	131	109
August 28,	191	123
August 30,	100	61
September 2,	119	120
September 5,	56	50
September 8,	165	13
September 11,	219	26
September 15,	265	19
September 18,	086	25
September 21,	026	8
	1399	584

Mildew began to develop on the unsprayed plants previous to the first picking, August 23. On August 30 the unsprayed plants were badly blighted, and by September 5 the leaves were dead. At this time the sprayed plants showed some mildew, but were not seriously injured until September 21, when the blight again attacked them and stopped the development of fruits.

DISCUSSION OF RESULTS.

Three years' work with Bordeaux on cucurbits has shown a decided increase in yield for the first and third years, when downy mildew was present, and a decided decrease in yield for the second year, when no fungi troubled the plants.

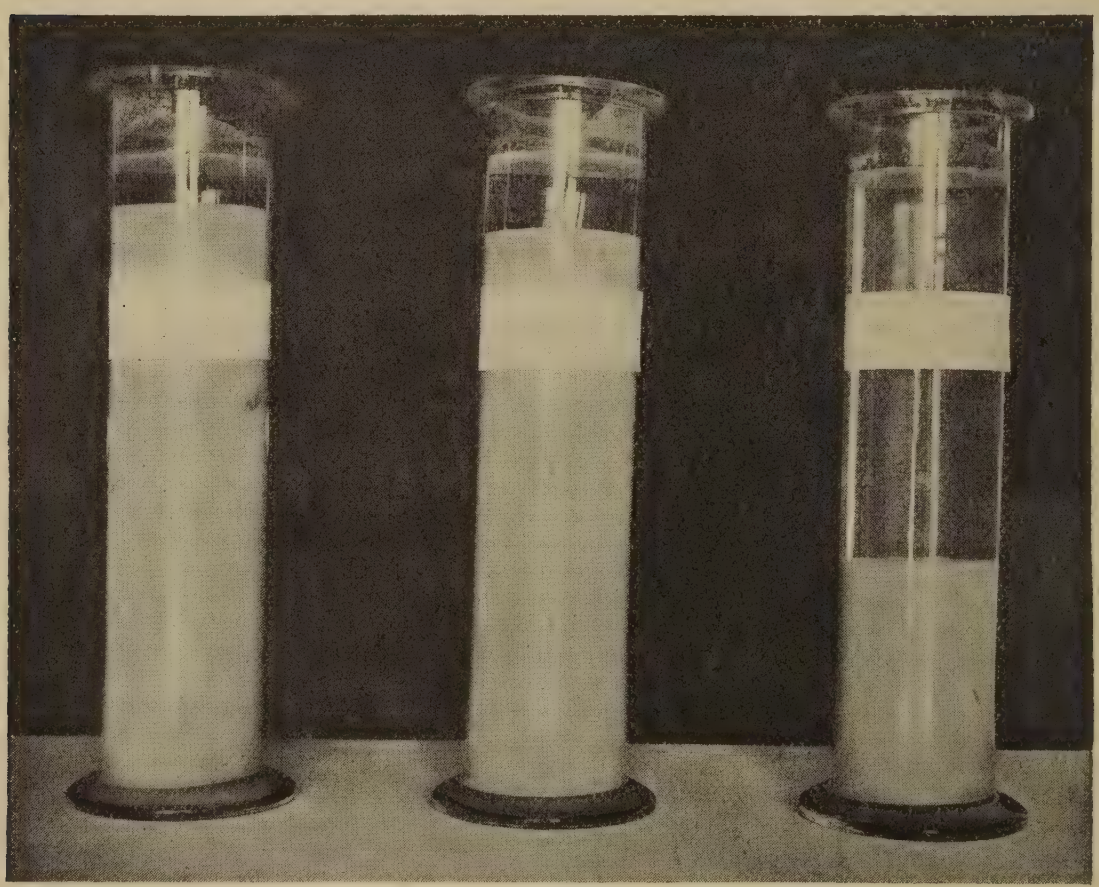
Melons treated the same way for the three seasons gave very similar results, with the exception that, in addition to mildew, anthracnose worked on the unsprayed melons in 1905.

The old question comes up again, "Will it pay to spray melons and cucumbers?" If we could know beforehand whether mildew would be present or not, we could easily answer this question; or if Bordeaux could be used on them without possible danger of injury, as it can on tomatoes and potatoes, it would pay to use it as an insurance. After mildew has made its appearance in the field it is generally too late to control it by spraying, though we have some evidence that

it can be controlled even then. A trial plot of a few hills of melons that were left without spraying were attacked by mildew. As soon as the mildew was noticed, an application of Bordeaux was given on one side of the plot. The disease was checked, and the melons developed. The other part of the plot, left unsprayed, did not bring its fruit to full size or maturity, owing to the destruction of the foliage before time for ripening.

BORDEAUX AND HOW TO MAKE IT.

Formulae for Bordeaux mixtures and descriptions for making it have been published so often that the subject ought to



Jaunta Lime. Canaan Lime. Prepared Lime.

FIG. 19. Bordeaux made from different kinds of lime.

be well understood; yet so many inquiries come to us regarding the subject and so much trouble has resulted from improperly made Bordeaux that we again give a detailed description, which may be followed in the field. The first requisite is to have good materials and good tools. Several different kinds of lime are used for making Bordeaux mixture. A lime which is

ground fine and prepared for immediate use and strongly recommended by the makers is on the market under several different names: prepared lime, limiod, etc. Canaan lime, which is a magnesium lime, made at Canaan, Conn., is the best known in this state, and a calcium lime known as "Jaunta" lime, made at Glens Falls, N. Y., is used to some extent.

Three samples of Bordeaux mixture were made from these different kinds of lime to compare them as to fineness of the precipitate, as determined by the time the mixture remained in suspension. The three samples were made at the same time and in the same way. The mixtures were put in glass jars, making a depth of mixture of ten inches. One and one-half hours after making, the precipitate of the Bordeaux from the prepared lime, or limoid, had settled five inches. That made from the Canaan lime had settled eighth-tenths of an inch, while that made from the Jaunta lime had settled six-tenths of an inch. At the end of three hours they had settled six inches, two and two-tenths inches, and one and one-fourth inches respectively.

The color of these different samples was quite different. That of the limoid mixture was a light turquoise blue, the Jaunta lime was indigo blue, while the Canaan lime mixture was half-way between the two. These differences in the mixtures were attributed to the differences in the chemical constituents of the three different limes. Samples of each were analyzed by Dr. B. B. Turner, Chemist of the Agricultural Experiment Station, with the following results:

Jaunta Lime		Canaan Lime		Limoid	
Calcium oxide	94%	Calcium oxide	53.5%	Calcium oxide	36.6%
Magnesium oxide	1%	Magnesium oxide	40 %	Magnesium oxide	28.9%
	95%		93.5%		65.5

Of the other elements making up the 100 per cent., carbon dioxide was by far the largest constituent. The action of lime in making Bordeaux mixture is to precipitate the copper sulphate and neutralize the free acid which it may contain. This is done by the calcium oxide in the lime. Consequently the lime having the largest proportion of calcium oxide is the best for this purpose. The mechanical condition of the slaked

Jaunta lime is better than that of the other makes, which is probably due to the smaller per cent. of calcium carbonate which it contains.

Much time may be saved by making stock solutions of both slacked lime and copper sulphate dissolved in water. In a sufficiently large water-tight box slake 100 pounds of lime. Add water to a known amount, say 50 gallons. This stock solution will keep in good shape during the season, if the lime is kept covered with water. If the lime is allowed to become dry, it will become air slaked and worthless for spraying purposes.

FIG. 19. Making Bordeaux mixture.

In another wooden receptacle, as a 50-gallon barrel, suspend from the top, by running a stick through the handles, a loose splint basket containing 100 pounds of copper sulphate, or blue stone. Fill the barrel with water, and let stand. In a day or two the copper sulphate will be dissolved, giving a solution of 2 pounds of copper sulphate to each gallon of liquid. Keep the barrel of solution covered or add water at intervals to make up for loss of water by evaporation.

Bordeaux mixture may be made from these stock solutions in various ways. The best mixture may be made by using an arrangement somewhat like that seen in cut.

Place two wooden cisterns, or barrels, on a platform so that their bottoms will be higher than the spray tank or barrel to be filled. If a 40-gallon spray barrel is to be used stir thoroughly the stock solution of copper sulphate and put 2 gallons of the solution (4 pounds copper sulphate) into one of the tanks, and add water to nearly 20 gallons. In the other tank put an equal amount of lime solution, and add water to nearly 20 gallons. Draw off the contents of both tanks through a 20 or 30 mesh copper strainer into the spray tank. Do not use a strainer made from cloth, as the fibres of the cloth clog the spray nozzles.

After the material is in the spray tank stir thoroughly, then dip out a small amount and test for unprecipitated copper sulphate by pouring in a few drops of a solution of ferrocyanide of potassium dissolved in water. If a dark brown coloration results, more lime is needed.

If the lime used in making the original solution is good, less than 4 pounds of it to 2 gallons of water will suffice; but an excess of lime does no harm and may prevent trouble.

Use nothing but wood, brass or copper, and rubber for spraying apparatus. Iron in the pump or connections is not only quickly eaten by the copper sulphate, but it forms scales that cause trouble by clogging the nozzles. The same difficulty will arise if the pump-hose, nozzles, and tank are not *thoroughly* washed every time after being used.

QUALITY OF MILK AFFECTED BY COMMON DAIRY PRACTICES.

BY W. A. STOCKING, JR.

The production of market milk is the most important branch of the dairy industry in Connecticut. According to the United States census of 1900 the annual production of milk in Connecticut amounts to 287,372,748 quarts, representing the product of something over 132,000 cows. About 35 per cent. of this milk is manufactured into butter and cheese while the remaining 65 per cent. is used as milk and cream. These figures serve as an indication of the importance of the milk industry in our state. While quite a percentage of the milk produced in the state is shipped to other states for consumption, principally to New York, Providence and Boston, a large part of it is consumed in the cities and villages in our own state. This being so, any problems relating to the quality of the milk produced should be of interest to both the producers and the consumers. For some years the state authorities have carefully looked after the chemical quality of the milk sold throughout the state with the result that milk of poor chemical quality has been practically driven from the market. The consumer is also protected against the use of chemical preservatives so that milk users need have very little fear of being defrauded either by a low content of fat and solids or by the use of preservatives. It is probably safe to say that the cream and butter-fat content of Connecticut milk averages as high as that of any state. The nearness of the producers to good markets also reduces the temptation to use preservatives. The production of milk from animals suffering from contagious diseases is also carefully guarded against by state laws and inspection. It has been, however, only during the last few years that any attention has been paid to the sanitary conditions under which milk has been produced and handled. With our increase in knowledge of the

relation which bacteria play to public health and our knowledge of the fact that milk is an ideal medium for the growth of nearly all species of bacteria, the value of careful bacteriological study of milk has become apparent. Physicians agree that certain diseases are easily communicated by bacteria being carried in milk, also that many infants and young children die each year as a result of impure milk; impure not from the use of adulterants or preservatives but as a natural result of the conditions under which it is produced and handled.

Milk is an extremely good food for a large number of species of bacteria and nearly all of the changes which render milk undesirable and unwholesome are caused by the presence and growth of certain species of this group of micro-organisms. Under ordinary methods of producing and handling, large numbers of bacteria get into milk. It is highly desirable that dairymen should know how to prevent the entrance of these organisms into the milk and to so handle it that the growth of those which do get in will be reduced to the minimum. It is possible to produce a grade of milk which shall contain but very few bacteria. This is demonstrated by some of the so-called "sanitary" or "certified" milks which are now on the market but these are produced at an increased cost and are sold at a price considerably above that of the regular market milk. The average consumer is unwilling to pay the increased price charged for this grade of milk yet insists on being supplied with a good wholesome article. At the present price which the average producer gets for his milk he cannot afford to greatly increase his cost of production. In order to meet the public demand for a better grade of milk he must therefore make use of inexpensive means for preventing the entrance, and controlling the growth, of bacteria in his milk. The thing of first importance is to prevent bacteria from getting into the milk. This must be borne in mind at every step in the production and subsequent handling but primarily while the milk is being drawn from the cow and until it is taken from the barn, for it is in the stable that milk usually gets its greatest bacterial contamination. In order to ascertain the actual effect of some of the common dairy practices upon the germ content of the milk the experiments given in this bulletin have been made.

FEEDING DRY FEEDS AT MILKING TIME.

The custom of feeding cows just before or during milking time is a common one. Many farmers claim that the cows will stand more quietly and give their milk down better if they are eating while being milked. The experience of many dairymen, however, shows this to be a mistaken idea. The man who has once adopted the plan of milking before any feeding is done seldom if ever cares to go back to the old method of having the cows eating while being milked. The average cow seems to be unable to divide her attention satisfactorily between two

FIG. 20. Barn in which the experiments recorded in this bulletin were made. The stables are located along the south side of the main barn where the small windows are seen.

operations and the result is that either she pays most of her attention to eating or else she pays more attention to the man who is milking her and is, therefore, unable to eat quietly and becomes annoyed and nervous because she cannot. There are but few cows which will not stand more quietly during the milking process if they have nothing else to attract their attention. If the cow is standing quietly she sees the milker when he approaches and steps in beside her. She also gives down her milk more freely than when she is attempting to eat at the

same time. On the other hand if the cow has her head down in the manger she probably will not see the milker when he approaches and the first intimation she has of his presence is when he speaks or touches her and if she is a nervous cow she will probably either jump or kick and then continue to annoy him with her tail during the entire process of milking. If the feeding is being done at the same time as the milking the annoyance is even greater since the cow is uneasy until she gets her feed and does not stand quietly or give down her milk freely. Cows which have been accustomed to eating during the milking process may bother for a few days if the feeding is postponed until after the milking but they become accustomed to the new order of things very quickly and after a few days will behave much more satisfactorily than they did when the two operations were done at the same time. It is not only more pleasant to do the milking before the feeding is done as a result of the better behavior of the cows but the sanitary and keeping qualities of the milk are also better than when the feeding has been done just before or during the milking period. All of the dry feeds such as the common grains, hays, etc., contain large quantities of dust which is thrown into the air by the handling. This dust is heavily charged with bacteria and the atmosphere of the stable thus becomes filled with these micro-organisms. As this dust settles into the milk pail it carries down with it the adhering bacteria and the germ content of the milk is thereby increased. At the same time the restlessness of the cow results in the dislodgment of a greater amount of dust and bacteria from the cow and the milker and these also fall into the milk. In order to determine the real importance of the greater contamination of the milk resulting from the increased dust caused by feeding dry feeds at milking time the writer conducted the experiments given in Table 20.

Feeding hay and dry grain.—For this work ten cows standing in a row in the College stable were used. These were divided into two groups of five cows each. One of these groups was milked before any feeding was done and a sample of the mixed milk obtained. The hay and grain were then fed and the other group of five cows was milked and a sample of their mixed milk taken. Both of these groups of cows were milked

into the Stadtmueller covered milk pail. The numbers of bacteria, therefore, are not as large in either case as they would have been had the milk been drawn into an ordinary open pail. Each day the two groups of five cows were alternated. This was done in order to avoid any error which might be caused by the difference in germ content of the udders of individual cows. Both sets of cows were milked by the same man and the treatment given to both lots was the same, the feeding being the

FIG. 21. The Stadtmueller covered pail used in these experiments.

only difference. The hay used in these experiments was of good quality and was not as dusty as the average hay fed to cows. The hay was put down through a chute from the floor above into the feeding alley and fed as would ordinarily be done without any unnecessary shaking. The grain was a mixture of wheat bran, cotton seed and gluten. This was drawn into measures from a chute in the feeding alley and distributed to the individual cows. The results of these experiments are given in Table 20.

TABLE 20.

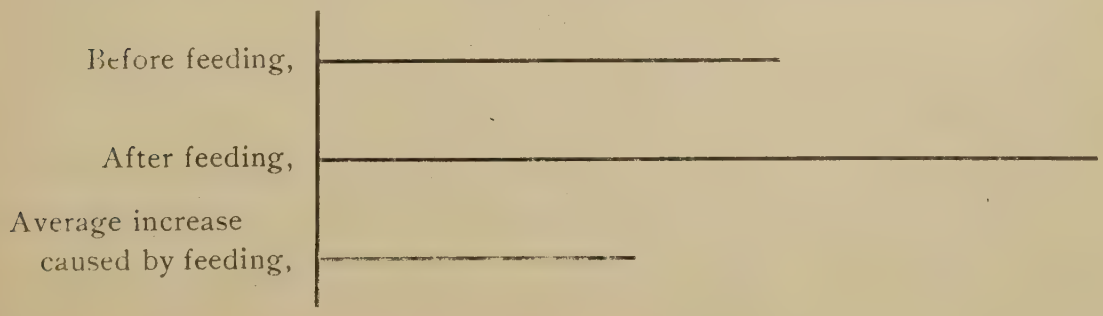
Number of Bacteria per cubic centimeter of milk before and after feeding hay and grain.*

NUMBER OF EXPERIMENT.	Date.	Kind of Sample.	Total Bacteria.	Acid Bacteria.	Liquefying Bacteria.
1, - - - - - -	May 4	Before feeding	352	46	15
1, - - - - - -	May 4	After feeding	1,452	552	44
2, - - - - - -	May 13	Before feeding	2,360	1,080	100
2, - - - - - -	May 13	After feeding	2,650	700	300
3, - - - - - -	May 17	Before feeding	1,866	733	33
3, - - - - - -	May 17	After feeding	2,383	616	83
4, - - - - - -	May 17	Before feeding	2,917	1,100	133
4, - - - - - -	May 17	After feeding	4,417	2,417	183
5, - - - - - -	May 18	Before feeding	950	633	17
5, - - - - - -	May 18	After feeding	2,917	933	117
6, - - - - - -	May 18	Before feeding	4,133	1,150	350
6, - - - - - -	May 18	After feeding	7,217	2,700	450
Averages, - - -	—	Before feeding	**2,096**	**790**	**108**
Averages, - - -	—	After feeding	**3,506**	**1,320**	**196**
Increase caused by feeding,	—	—	**1,410**	**530**	**88**

* One cubic centimeter of milk equals about 20 drops.

It will be noticed in the column marked "total bacteria" that the number contained in the milk drawn before the feeding was done is in each case smaller than was obtained in the milk drawn after the feeding had been done. In some cases the difference is very striking. The average number of bacteria found in the milk drawn before the feeding was done is 2,096 per cubic centimeter while the average for the milk drawn after the feeding had been done is 3.506 per cubic centimeter, making a difference in favor of not feeding previous to milking of 1,410 bacteria per cubic centimeter. These relative numbers are shown by the accompanying diagram.

Diagram showing the above averages for the total bacteria.



There is also a very marked difference in the number of acid producing organisms in the two kinds of milk, this difference usually being decidedly in favor of the milk drawn before the feeding was done, there being an average difference of 530 acid producing bacteria per cubic centimeter in favor of the milk drawn before the cows were fed. The same relation exists even more strikingly in the liquefying or peptonizing group of bacteria as shown in the last column of the table. In every experiment the milk drawn after the feeding was done contained larger numbers of this group of organisms than did the corresponding milk drawn before feeding, the average being an increase of more than 80 per cent. The results of these experiments show that the amount of dust produced in the stable by feeding hay and dry grain causes a decided increase in the number of bacteria which gain access to the milk and from a sanitary standpoint it is a bad practice to feed these materials until after the milking has been completed.

Feeding dry corn stover at milking time.—The effect of the increased dust caused by feeding hay and grain was so marked in the foregoing experiments that it was thought desirable to determine the effect of feeding dry corn stover just before milking. In these experiments two cows standing side by side were used. They were both milked by the same man into the Stadtmueller covered milk pail. One was milked before any feeding was done. Dry corn stover was then fed to the stock in that section of the barn and the other cow milked immediately. The order of milking the two cows was alternated each day in order to prevent any error which might be due to the difference in germ content of the udders of the two cows. The corn stover which was used in these tests was of extra fine quality and contained a much smaller amount of dust than corn stover usually contains. The stover was put down into the feeding alley from the floor above an hour or two before milking time and left in a pile in the alley. From this pile it was taken to the different animals in a bushel basket. This did not produce nearly as much dust in the air at milking time as there would have been had the stover not been put down until it was needed for feeding. In Table No. 21 are given the results of these experiments.

TABLE 21.

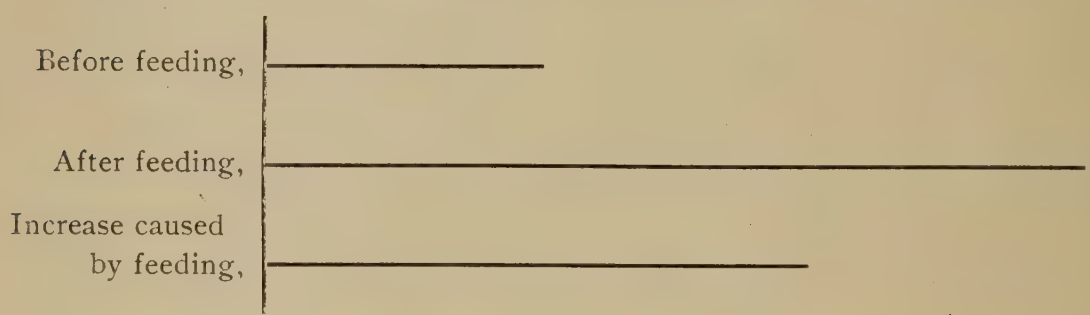
Number of bacteria per cubic centimeter of milk before and after feeding dry corn stover.

NUMBER OF EXPERIMENT.	Date.	Nature of Sample.	Total Bacteria.	Acid Bacteria.	Liquefying Bacteria.	Molds.
1, - - - -	Feb. 8	Before feeding	579	279	0	379
1, - - - -	Feb. 8	After feeding	11,775	1,088	121	429
2, - - - -	Feb. 9	Before feeding	1,933	321	4	38
2, - - - -	Feb. 9	After feeding	2,442	1,079	0	33
3, - - - -	Feb. 17	Before feeding	2,688	510	0	160
3, - - - -	Feb. 17	After feeding	1,728	540	8	86
4, - - - -	Feb. 18	Before feeding	113	40	0	8
4, - - - -	Feb. 18	After feeding	379	121	0	58
5, - - - -	Feb. 22	Before feeding	854	333	0	4
5, - - - -	Feb. 22	After feeding	1,954	633	13	8
Averages, - -	—	Before feeding	**1,233**	**297**	**1**	**118**
Averages, - -	—	After feeding	**3,656**	**692**	**28**	**123**
Increase caused by feeding, - -	—	—	**2,423**	**395**	**27**	**5**

The only change of conditions between the milk drawn before and after feeding the corn stover was the increased dust in the atmosphere. It will be noticed in the table that in all but one of the experiments the milk drawn after the stover was fed contained much larger numbers of bacteria than did the milk drawn before the feeding was done. In experiment 3 it is evident that bacteria from some other source gained access to the milk in such numbers as to more than counteract the effect of the increased dust caused by feeding. The average for the samples taken before feeding is 1,233 and for the samples taken after feeding, 3,656 or a difference of 2,423 bacteria per cubic centimeter in favor of the milk drawn before the stover was fed. It may also be noticed that there is a decided increase in the number of acid producing organisms as a result of feeding the corn stover. The number of liquefying organisms was in most cases remarkably small in these experiments but seemed to be greatly increased by feeding. Most of these samples of milk contained quite a large number of molds in addition to the bacteria, indicating that the stable atmosphere was badly contaminated by molds from the corn stover. There seemed to be a large num-

ber of mold spores in the atmosphere even before the feeding was done. This condition was no doubt caused by the fact that the corn stover had been thrown down into the feeding alley a short time before milking time. If it had not been thrown down until after the first cow had been milked it is highly probable that the difference in the numbers of bacteria and molds in the two samples of milk would have been even greater than those shown in the table. The relative numbers of bacteria as shown by the averages of these experiments are illustrated graphically in the accompanying diagram.

Diagram showing the above averages for the total bacteria.



The results of these experiments make it apparent that the number of bacteria gaining access to milk is greatly increased if dry corn stover is fed just before or during the time of milking.

WIPING OFF THE COW WITH A DAMP CLOTH.

In these experiments ten cows were used, these being divided into two lots of five cows each. At each milking one of these groups of cows was milked without any special care being taken to wipe off dust and other loose dirt. The other group of five cows had the flank and udder wiped with a cloth which had been dampened in clear water. No antiseptic or germicide was used. The next day the order of milking the two groups of cows was reversed so that every other day each group was milked without being wiped off while the other group was milked after being wiped with a damp cloth. These cows were all milked by the same man into a Stadtmueller covered pail. The samples were taken from the mixed milk of each group of five cows. The figures given in Table No. 22 show the results obtained under these two conditions of milking.

TABLE 22.

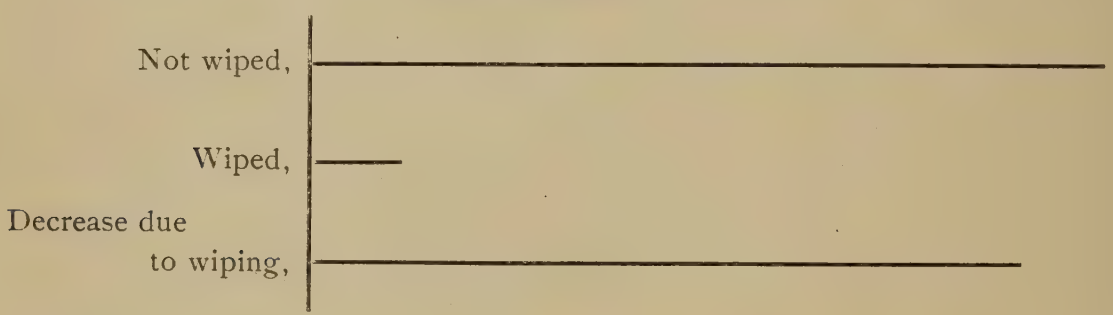
Showing numbers of bacteria in milk before and after the udder and flank were wiped with damp cloth.

NUMBER OF EXPERIMENT.	Date.	Treatment of Cows.	Total Bacteria.	Acid Bacteria.	Liquefying Bacteria.
1, - - - - -	April 13	Not wiped	1,070	329	21
1, - - - - -	April 13	Wiped	1,030	467	100
2, - - - - -	April 13	Not wiped	2,780	958	142
2, - - - - -	April 13	Wiped	530	204	71
3, - - - - -	April 14	Not wiped	64,590	39,192	21
3, - - - - -	April 14	Wiped	250	42	0
4, - - - - -	April 14	Not wiped	490	113	0
4, - - - - -	April 14	Wiped	800	313	50
5, - - - - -	April 15	Not wiped	725	250	37
5, - - - - -	April 15	Wiped	575	421	37
6, - - - - -	April 15	Not wiped	1,310	363	66
6, - - - - -	April 15	Wiped	310	91	13
7, - - - - -	April 16	Not wiped	505	29	87
7, - - - - -	April 16	Wiped	325	25	4
8, - - - - -	April 16	Not wiped	800	133	33
8, - - - - -	April 16	Wiped	754	71	50
9, - - - - -	May 26	Not wiped	210	75	0
9, - - - - -	May 26	Wiped	100	17	0
10, - - - - -	May 26	Not wiped	660	175	158
10, - - - - -	May 26	Wiped	385	83	33
11, - - - - -	May 27	Not wiped	15,475	4,050	342
11, - - - - -	May 27	Wiped	3,025	425	200
12, - - - - -	May 28	Not wiped	1,130	142	25
12, - - - - -	May 28	Wiped	590	100	42
13, - - - - -	May 31	Not wiped	2,010	392	116
13, - - - - -	May 31	Wiped	650	150	17
Averages, - - - -	—	Not wiped	7,058	3,554	81
Averages, - - - -	—	Wiped	716	185	47
Decrease due to wiping, -	—	—	6,342	3,369	34

In nearly all of these experiments the milk drawn from the cows which were not wiped with a damp cloth contained more bacteria than that drawn from the cows which were wiped. In a number of experiments the differences are very striking. There is only one experiment, No. 4, where the milk from the wiped cows contained more bacteria than from the unwiped. This condition, of course, could not result from the wiping but was evidently caused by some other condition. By averaging all of the samples taken from the cows which were not wiped it is found that the germ content of the milk was 7,058 bacteria per cubic centimeter, while the average of the samples taken

from the cows which were wiped with a damp cloth was but 716, making a difference in favor of the wiping of 6,342 bacteria per cubic centimeter. A part of this striking difference is, of course, due to the relatively large number in the unwiped sample in experiment No. 3, but there seems to be no reason why this experiment should be omitted from the average since it was in every way a fair test. Even if this experiment were omitted the difference would still be very decidedly in favor of the practice of wiping the udders. One of the benefits gained by the practice of using a damp cloth is the prevention of just such abnormally high numbers of bacteria as occurred in experiment No. 3. At the same time this practice results uniformly in a much smaller germ content than the milk would otherwise contain. The relative value of the numbers given in the averages for the first column in the table are strikingly shown by the accompanying diagram.

Diagram showing the relative value of the above averages for the total bacteria.



While the benefit produced by the wiping is not quite so uniform as in the total number still it is in most cases very marked in both the acid and liquefying groups of bacteria and the averages for these columns show that the practice of wiping the udders has a very decided influence in excluding these bacteria from the milk. It, perhaps, should be stated here that the cows used in these experiments were kept in much better condition as regards cleanliness than the average dairy herd. The results obtained by these experiments are, therefore, not abnormal. On the contrary the differences shown here are probably much less striking than would be found if the cows were not kept in such good condition. In fact a few experiments which have been made by the writer in stables where the conditions are not as good show this to be the case.

BRUSHING THE COWS AT MILKING TIME.

It is a common practice with some dairymen to go through the stable and brush their cows just before they begin milking. In order to determine the effect of this practice upon the germ content of the milk the following series of experiments was made. The details of these experiments are practically the same as those outlined in connection with the wiping tests. One of the groups of five cows was milked in the usual way. The other group was then brushed with a common stiff broom

TABLE 23.

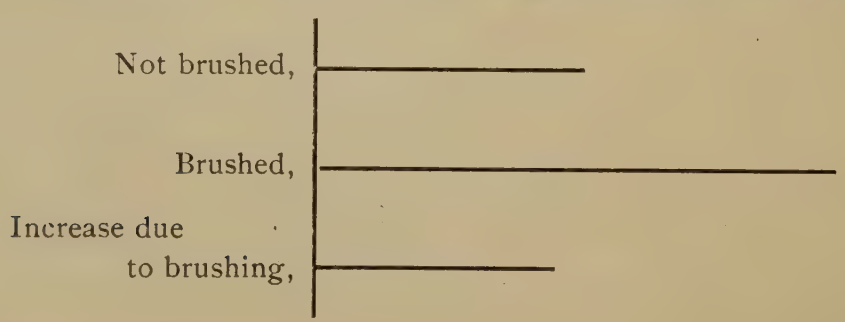
Showing the germ content of the milk drawn before and after brushing the cows.

Number of Experiment.	Date.	Treatment of Cows.	Total Bacteria.	Acid Bacteria.	Liquefying Bacteria.
1,	March 21	Not brushed	567	25	67
1,	March 21	Brushed	900	67	25
2,	March 22	Not brushed	242	17	25
2,	March 22	Brushed	13,742	1,375	550
3,	March 22	Not brushed	142	8	17
3,	March 22	Brushed	758	42	92
4,	March 23	Not brushed	225	42	17
4,	March 23	Brushed	1,242	275	42
5,	March 23	Not brushed	908	267	92
5,	March 23	Brushed	1,392	258	42
6,	March 24	Not brushed	333	67	0
6,	March 24	Brushed	1,292	367	0
7,	March 25	Not brushed	467	42	17
7,	March 25	Brushed	625	175	0
8,	March 26	Not brushed	908	200	8
8,	March 26	Brushed	1,883	383	33
9,	March 27	Not brushed	363	25	25
9,	March 27	Brushed	508	79	12
10,	April 1	Not brushed	842	217	33
10,	April 1	Brushed	1,308	300	37
11,	April 1	Not brushed	900	221	33
11,	April 1	Brushed	2,533	529	121
12,	April 2	Not brushed	6,321	484	17
12,	April 2	Brushed	1,025	188	108
13,	May 18	Not brushed	4,330	1,354	458
13,	May 18	Brushed	4,300	1,200	525
14,	May 18	Not brushed	350	20	0
14,	May 18	Brushed	500	100	50
Averages,	—	Not brushed	1,207	213	59
Averages,	—	Brushed	2,286	381	117
Increase as result of brushing,	—	—	1,079	168	58

brush such as is commonly used in dairy barns. This group of cows was then milked and samples from the two lots of milk taken as previously described. Table No. 23 shows the numbers of bacteria that were found in the two kinds of samples taken in this way.

A study of the column marked "total bacteria" shows that there was very uniformly a higher number of bacteria in the milk drawn from the cows which had just been brushed than there was in the milk drawn from the cows which were milked before the brushing was done. These results are not surprising to those who appreciate the fact that the hair and skin of the cow normally carry large numbers of bacteria. The dust and hair which are set free by the brushing must necessarily fill the air with bacteria in the vicinity of the cow and this dust will fall into the milk pail carrying bacteria with it, if the cow is milked before the dust has had a chance to settle. In experiment 13 there is practically no difference in the germ content of the milk from the two groups of cows. Experiment 12 is the only one where the milk from the unbrushed cows contains a higher germ content than does the milk from the brushed group. It is evident that this condition was caused by some unusual source of contamination of the milk from the unbrushed cows. With this one exception the evidence is practically unanimous against the practice of brushing *at* or *just before* the process of milking. The influence of the brushing is in most of the experiments quite marked upon both the acid producing and liquefying groups of bacteria. The following diagram shows the relative numbers of bacteria as given in the averages for the column marked "total numbers" of bacteria. The cows used in these experiments were unusually clean and the amount of dust stirred up by the brushing was, therefore,

Diagram showing the above averages for the total bacteria.



small as compared with the amount which would be caused by the same operation upon cows which were not so well kept. No doubt the difference due to this operation would be even more striking in the average Connecticut dairy.

It is evident that the practice of brushing just at milking time should be avoided, but if the brushing were done long enough before milking so that the dust would have a chance to settle it would result beneficially to the germ content of the milk.

REJECTING FORE-MILK.

It is a common practice in dairies where special effort is made to obtain milk with a low germ content, to discard more or less of the fore-milk. It has been found by various experimenters that the first few streams of milk normally contain decidedly more bacteria than the main part of the milk. This has led to the practice of discarding from two to four jets of milk from each quarter of the udder before the regular milking is commenced in stables where a special effort is made to keep the bacteria content of the general product as low as possible.

BACTERIA IN FORE-MILK.

The experiments in Table No. 24* were made to determine the amount of milk necessary to be discarded in order to remove the surplus bacteria usually found in the fore-milk.

The method of making these experiments was as follows: The flank and udder of the cow were carefully wiped with a damp cloth. The first two jets of milk from each quarter were then drawn into a sterile flask held in a horizontal position. The next two jets from each quarter were then drawn into the milk pail, another sample was then drawn into a sterile flask in a similar manner to the first, this sample including the fifth and sixth jets from each quarter. Two more streams were then drawn into the pail and another sample taken, this procedure being continued until four samples were obtained. A fifth sample was also taken from near the end of the milking.

It will be seen by looking at Table No. 5 that the first two streams of milk from each quarter of the udder contained in each case decidedly higher numbers of bacteria than did the

* The actual work of these experiments was done by H. D. Edmond, a graduate student in dairy bacteriology.

TABLE 24.

Bacteria per cubic centimeter in different parts of the fore-milk.

NUMBER OF EXPERIMENT.	Streams 1 and 2.	Streams 5 and 6.	Streams 9 and 10.	Streams 13 and 14.	Strippings.
1,	1,940	550	250	275	216
2,	25,200	5,391	285	218	101
3,	5,491	2,096	430	820	144
4,	7,941	1,350	125	216	156
Average,	**10,143**	**2,347**	**272**	**382**	**204**

fifth and sixth streams, but these also contained many more bacteria than were found in the ninth and tenth streams. After that point the germ content did not seem to decrease materially. These experiments would indicate that in order to exclude the fore-milk containing a high germ content it is necessary to discard at least six good sized streams from each quarter of the udder. It is obvious that this means a considerable quantity of milk and would mean quite an appreciable financial loss in a herd of much size.

GERM CONTENT OF MILK AFFECTED BY FORE-MILK.

While the number of bacteria in the first few streams of milk is normally considerably higher than is contained by the main part of the milk, the writer was of the opinion that when this surplus of organisms found in the fore-milk is mixed with the entire milk of the cow the total increase in bacteria would not be very great. To determine this point the following series of experiments was made.

Method of experiment.—In the main the details of these experiments were similar to those which have already been described. At each milking the first three streams from each quarter of the udder were drawn from five cows and the remainder of the milk drawn in the usual way. Another group of five cows was milked without rejecting the fore-milk. Samples of the mixed milk of each of these groups of five cows were taken for the determination of the bacteria content. The treatment given the two groups of cows was alternated from

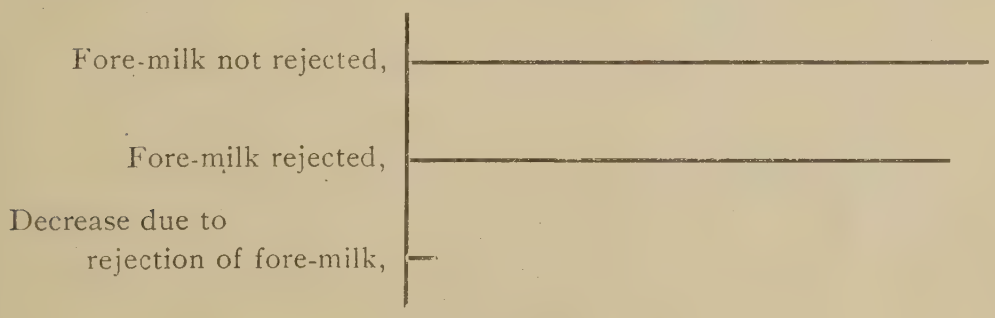
day to day so that the group from which the fore-milk was rejected on one day had the entire milk drawn on the following day. In this way any abnormal variations due to peculiar germ content of individual udders was obviated.

TABLE 25.

Bacterial content of milk as affected by rejection of the fore-milk.

NUMBER OF EXPERIMENT.	Date.	Treatment of Cows.	Total Bacteria.	Acid Bacteria.	Liquefying Bacteria.
1,	April 20	Fore-milk not rejected	321	154	8
1,	April 20	Fore-milk rejected	366	25	13
2,	April 20	Fore-milk not rejected	304	138	16
2,	April 20	Fore-milk rejected	921	200	63
3,	April 21	Fore-milk not rejected	567	133	4
3,	April 21	Fore-milk rejected	317	67	21
4,	April 21	Fore-milk not rejected	575	350	33
4,	April 21	Fore-milk rejected	859	242	33
5,	April 22	Fore-milk not rejected	550	67	8
5,	April 22	Fore-milk rejected	471	63	25
6,	April 22	Fore-milk not rejected	883	221	4
6,	April 22	Fore-milk rejected	450	121	21
7,	April 25	Fore-milk not rejected	233	71	0
7,	April 25	Fore-milk rejected	363	13	38
8,	April 25	Fore-milk not rejected	746	375	0
8,	April 25	Fore-milk rejected	246	58	46
Averages,	—	Fore-milk not rejected	**522**	**189**	**9**
Averages,	—	Fore-milk rejected	**499**	**99**	**33**
Difference due to rejection of fore-milk,	—	—	**−23**	**−90**	**+24**

Diagram showing the above averages for the total bacteria.



It may be seen by a study of Table No. 25 that the total numbers of bacteria in all of the tests ran very low as a result of the general care and cleanly condition existing about the stable. It will, however, be seen that in four of the experiments the

milk from the five cows having the fore-milk rejected contained a somewhat higher germ content than the corresponding milk from the five cows where the fore-milk was included. In the other four experiments there was a difference in favor of the rejection of the fore-milk. The average for the eight samples which included the fore-milk was 522 bacteria per cubic centimeter while the average for the samples from which the fore-milk had been excluded was 499 bacteria per cubic centimeter, making a difference of 23 bacteria in favor of discarding the fore-milk. This difference is so small that it is of no significance from a practical standpoint. These experiments would seem to show that the effect upon the total milk caused by the larger germ content of the fore-milk is so slight that the germ content will be influenced to a much greater extent by other conditions which may wholly offset the increase caused by the fore-milk being mixed with the entire milk from the cow. If one wishes to produce milk where an extremely low germ content is desirable it would probably be worth while to exclude a certain amount of the fore-milk, but for milk of a moderately high grade this precaution is not of enough importance to warrant the loss of the milk necessary to be discarded in order to exclude the surplus bacteria existing in the milk cistern.

LEAVING MILK IN THE UDDER AFFECTS THE GERM CONTENT OF THE MILK AT THE NEXT MILKING.

It has long been known by good dairymen that it is highly desirable that no milk should be left in the udder at the time of milking, or in other words, that the cow should be stripped as dry as possible. This is desirable because the strippings always contain a much higher percentage of fat than does the preceding milk, also because the habit of milking a cow dry has a tendency to maintain or even increase the milk flow, whereas if a small amount of milk is left in the udder each time it will cause the cow to decrease more rapidly than she should in her milk flow. The effect of the practice of not milking the cow dry upon the bacteria content has never been determined so far as the writer knows and it was in order to determine this point that the experiments given in Table No. 26 were made.

Method of experiments.—The details of these experiments were as follows: One cow was taken and milked aseptically

into flasks, all possible precautions being taken to avoid contamination from external sources. The entire milk of the cow thus obtained was carefully sampled and plate cultures made to determine the numbers of bacteria present. On some days the udder was milked as dry as possible, while on other days a small amount of strippings was left in the udder. The method of milking as given in the table indicates the treatment at the milking preceding the one at which the sample was taken. For example, "milked dry" on the P. M. of June 3d means that the cow was stripped as dry as possible the morning of June 3d, while "not milked dry" the morning of June 8th means that a small amount of strippings was left in the udder the night of June 7th.

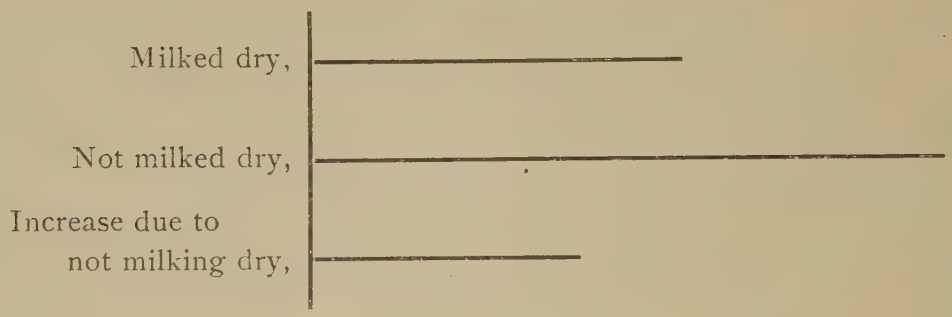
It was found as a result of this method of work that in the majority of cases the germ content of the milk was larger when

TABLE 26.

Bacterial content of milk affected by method of milking at previous milking.

NUMBER OF EXPERIMENT.	Date.	Treatment at Previous Milking.	Total Bacteria per cc.	Increase as result of not milking dry.
1,	June 3	Milked dry	13,825	—
1,	June 4	Not milked dry	22,604	8,779
2,	June 8	Milked dry	6,865	—
2,	June 8	Not milked dry	17,607	10,742
3,	June 9	Milked dry	1,357	—
3,	June 10	Not milked dry	2,346	989
4,	June 11	Milked dry	4,800	—
4,	June 10	Not milked dry	12,112	7,312
5,	June 21	Milked dry	3,129	—
5,	June 21	Not milked dry	13,390	10,261
6,	June 22	Milked dry	21,691	—
6,	June 22	Not milked dry	32,296	10,605
7,	June 23	Milked dry	783	—
7,	June 23	Not milked dry	1,371	588
8,	June 24	Milked dry	3,452	—
8,	June 24	Not milked dry	2,153	−1,299
9,	June 28	Milked dry	6,812	—
9,	June 29	Not milked dry	5,175	−1,637
10,	July 1	Milked dry	2,742	—
10,	June 30	Not milked dry	4,185	1,443
Average,	—	Milked dry	**6,542**	—
Average,	—	Not milked dry	**11,324**	—
Increase due to not milking dry,	—	—	**4,779**	—

Diagram showing the relation existing between the above averages.



a small amount of strippings was left in the udder at the preceding milking. In many cases this difference was very marked as is shown by some of the experiments in the Table No. 26 which fairly represents the results obtained in a long series of tests. Occasionally the results were reversed, the germ content of the milk being larger when the cow was milked dry at the preceding milking, but in most cases, however, the practice of leaving a small amount of milk in the udder resulted in a considerably increased germ content of the milk at the following milking. This result seems surprising since there must always be a sufficient quantity of milk in the udder, even where

TABLE 27.

Germ content of strippings is normally greater than that of the preceding milk.

Number of Experiment.	Date.	Bacteria per C. C.	
		Strippings.	Earlier Milk.
1,	May 22	775	650
2,	July 14	51	34
3,	July 18	281	104
4,	July 23	40	9
5,	July 24	615	477
6,	August 16	106	85
7,	October 18	292	212
8,	October 20	202	85
9,	November 1	88	26
Average,	—	272	187

the most thorough stripping is practiced, to furnish abundant food for any bacteria which may remain in the udder after milking. It is probable, therefore, that it is not a question of food supply which causes this greater increase when a small amount of milk is left undrawn. The operation of stripping usually brings more bacteria from the udder in each cubic centimeter of milk than are contained in the milk just preceding the strippings. This fact may be shown by figures given in Table No. 27.

This condition is probably caused by the more vigorous manipulation of the udder necessary to draw the strippings, thus dislodging from the milk ducts bacteria which have remained there during the earlier part of the milking. This means that when a cow is thoroughly stripped a smaller number of bacteria will be left in the udder. The multiplication of these organisms during the time intervening before the next milking period would not produce as great a number of bacteria as would have been produced had a greater number been left in the udder at the preceding milking. It is probable that this is the explanation for the fact that there is a greater germ content in the milk when the cow has not been stripped dry at the preceding milking. While these experiments were conducted with but a few cows there is no reason to suppose that the conditions were not normal and that the same conditions would not be found to exist in all cows. This adds one more reason why cows should be thoroughly stripped.

INDIVIDUAL MILKERS AFFECT GERM CONTENT OF MILK.

Every dairyman knows that some milkers will normally keep their milk much cleaner than others under the same conditions as to stable, dairy utensils, and other surroundings. Some men naturally will always have their milk reasonably clean even though the conditions are not especially favorable for the production of clean milk while other men will naturally always have their milk dirty even if the conditions of cleanliness are good. The importance of cleanly milkers is becoming more and more important in proportion to the public demand for clean milk, and it is becoming more and more necessary that dairymen take this characteristic into account in hiring men who are to do their milking for them. In order to get some definite data in

regard to the relative cleanliness of individual milkers the experiments given in Tables Nos. 28 and 29 were carried on. In the first series the milk of five of the College students was compared with an equal quantity of milk from the two regular men who were at that time doing the milking in the College stable. The method of the experiments was as follows: The students milked five cows and poured the entire milk into a forty quart can. The regular men also milked five cows and the milk was put into another can. A sample was then taken from each of these cans and tested for the number of bacteria which it contained. In all, the work of five students was compared in this way with the work of the regular men. The students had had some work in dairy bacteriology and the production of clean milk while the two regular men had not had such training. Both students and men, however, followed the same course of procedure. The flank and udder were wiped with a damp cloth and the milk drawn into the Stadtmueller covered pail. The results are, therefore, comparable.

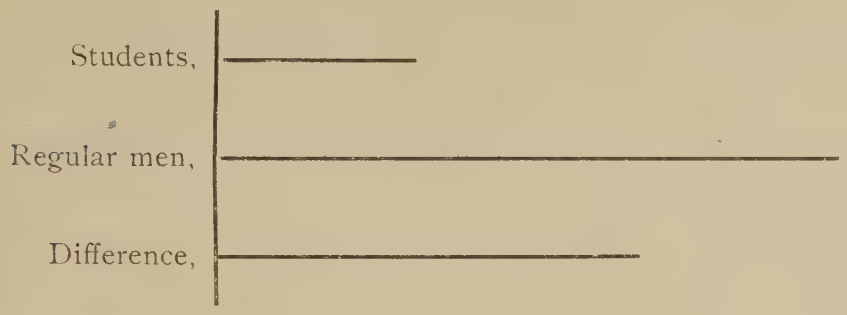
TABLE 28.

Bacterial content of milk varies with milkers.

DATE.	Milker.	Bacteria per c. c. of Milk.	Difference in favor of Student.
October 2,	Student No. 1	1,438	—
October 2,	Regular men	6,150	4,712
October 5,	Student No. 2	1,604	—
October 5,	Regular men	2,167	563
October 7,	Student No. 3	388	—
October 7,	Regular men	2,900	2,512
October 13,	Student No. 4	863	—
October 13,	Regular men	975	112
October 16,	Student No. 5	275	—
October 16,	Regular men	2,038	1,763
Average,	Students	**914**	—
Average,	Regular men	**2,846**	**1,932**

It will be noticed that in every case the number of bacteria found in the milk drawn by students was decidedly smaller than was found in the milk drawn by the regular men at the same milking. In some cases the milk drawn by the regular men contained more

Diagram showing the above averages in graphic form.



than nine times as many bacteria as did that drawn by the student, while the average of the five comparisons shows that the milk drawn by the students contained but one-third as many bacteria as that drawn by the regular men. These average differences are brought out by the diagram in connection with Table No. 28. All of the stable conditions were, of course, the same for both and the difference in results must be attributed to the difference in care exercised by the individual men.

In Table No. 29 are given the results of a series of comparisons between the same two men mentioned above and a graduate of the College who was at the time in charge of the dairy herd. In each case five cows were milked by him and the milk compared with that from five cows milked by the two men.

These results are even more striking than those given in the preceding table. The men all had the same instructions in regard to cleaning the udder and followed the same methods of milking but the one uniformly obtained milk with a low germ content while the others obtained milk with several times the number of bacteria per cubic centimeter. In some cases the differences are extreme, as in experiments 7 and 8. The averages for the nineteen experiments given here show that one man obtained milk containing 2,455 bacteria per cubic centimeter, while under the same conditions the other men obtained milk with 17,100, or seven times the number of bacteria in the same quantity of milk. These relative values are strikingly illustrated by the diagram at the bottom of the table. These differences can be accounted for only by the difference in the individual care used in their work, by the different men. These results emphasize very strikingly the important part which the

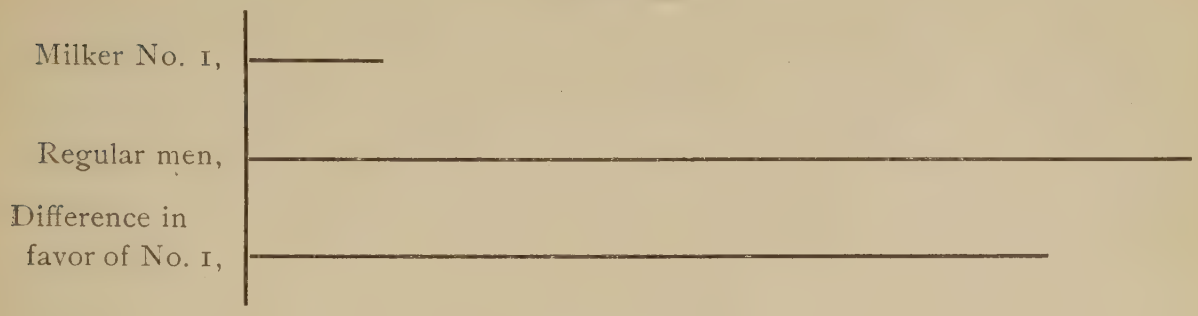
individual milker plays in the production of clean milk and the relative value of such men as milkers in dairies where a low germ content and a high quality of milk is desired.

TABLE 29.

Bacterial content of milk drawn by different milkers.

NUMBER OF EXPERIMENT.	Date.	Milker.	Total Bacteria.	Acid Bacteria.	Liquefying Bacteria.
1,	April 28	No. 1	2,463	433	104
1,	April 28	Regular men	2,756	580	42
2,	April 29	No. 1	2,050	71	608
2,	April 29	Regular men	4,467	1,758	733
3,	April 29	No. 1	1,654	200	596
3,	April 29	Regular men	2,575	933	208
4,	April 30	No. 1	1,258	413	21
4,	April 30	Regular men	5,600	2,908	492
5,	April 30	No. 1	907	258	13
5,	April 30	Regular men	2,690	690	130
6,	May 2	No. 1	1,606	263	44
6,	May 2	Regular men	10,050	1,216	433
7,	May 2	No. 1	142	46	0
7,	May 2	Regular men	12,617	2,275	242
8,	May 3	No. 1	731	142	25
8,	May 3	Regular men	180,350	10,133	1,883
9,	May 4	No. 1	1,452	552	44
9,	May 4	Regular men	13,700	7,633	116
10,	May 13	No. 1	4,933	2,467	133
10,	May 13	Regular men	13,604	4,521	292
11,	May 13	No. 1	2,650	700	300
11,	May 13	Regular men	2,104	688	63
12,	May 15	No. 1	2,917	1,100	133
12,	May 15	Regular men	4,938	1,771	125
13,	May 15	No. 1	1,866	733	33
13,	May 15	Regular men	5,688	2,125	229
14,	May 16	No. 1	4,133	1,150	350
14,	May 16	Regular men	17,583	4,271	375
15,	May 16	No. 1	950	633	17
15,	May 16	Regular men	4,104	1,063	500
16,	May 17	No. 1	4,417	2,417	183
16,	May 17	Regular men	6,813	2,104	292
17,	May 17	No. 1	2,383	616	83
17,	May 17	Regular men	2,854	833	208
18,	May 18	No. 1	7,217	2,700	450
18,	May 18	Regular men	24,938	6,250	1,542
19,	May 18	No. 1	2,917	933	117
19,	May 18	Regular men	7,583	1,979	567
Average,	—	No. 1	**2,455**	**833**	**171**
Average,	—	Regular men	**17,105**	**2,827**	**445**
Difference in favor of No. 1,	—	—	**14,650**	**1,994**	**274**

Graphic comparison of the above averages for total numbers of bacteria.



SUMMARY.

The experiments described in the preceding pages seem to justify the following conclusions:

1. Feeding hay and dry grain just before or at milking time fills the atmosphere of the stable with dust. This dust then settles into the milk pail carrying bacteria with it, thus increasing the germ content of the milk.

2. Feeding dry corn stover just before or at milking time has the same effect as the feeding of hay and grain only in a more marked degree since corn stover usually contains more dust and bacteria than does hay and grain.

3. Wiping the flank and udder of the cow with a damp cloth just before milking is a very efficient method for reducing the number of bacteria which fall into the milk pail.

4. The practice of brushing cows *at* milking time is undesirable. The hair and dust which are thus set free into the atmosphere settle into the milk pail during the process of milking and very materially increase the germ content of the milk.

5. Stripping a cow dry tends to reduce the number of bacteria found in the milk at the next milking while leaving a small amount of strippings in the udder increases the number of bacteria which the milk will contain at the next milking. This is probably due to the fact that the greater manipulation necessary to thoroughly strip the cow removes many bacteria which would otherwise remain in the udder to multiply during the time before the next milking.

6. In order to remove the surplus of bacteria existing in the milk cistern it is necessary to discard the first five or six full streams of milk from each quarter of the udder. The removal of the fore-milk results in a slightly smaller germ content of the remaining milk but the difference is so small that this practice is probably only valuable where an extremely low germ content is desired.

7. The intelligence and personal habits of the individual milker is an important factor in determining the germ content of the milk. This factor must be taken into account in the production of clean and high grade milk.

A CLASSIFICATION OF DAIRY BACTERIA.

BY H. W. CONN, W. M. ESTEN AND W. A. STOCKING.

In the Annual Report of this Station for 1899 there was published a preliminary report upon the Classification of Dairy Bacteria as they had been studied in our laboratory. This has been up to the present the only attempt made at a systematic arrangement of these bacteria and it has been used somewhat extensively by bacteriologists. The large amount of work that has been done since that time and the great changes that have occurred in the methods of description and diagnosis of bacteria have made that paper no longer a correct representation of the present knowledge of dairy bacteria. Requests for that paper are still occasionally received, but inasmuch as it is so far from representing the present state of the known facts it is no longer regarded as advisable to distribute the paper in question. For this reason, as well as because of the accumulation of a large amount of further information, it is thought wise to publish at the present time a second paper upon the same subject, bringing the facts up to date. The previous paper has served a purpose. It was recognized when it was published, that it was only a temporary expedient, designed as a stepping stone toward something better. It is hoped that the present may serve a better purpose in the same direction and bring us nearer to a clear, satisfactory classification of dairy bacteria.

Since the publication of the previous paper we have done a large amount of work upon these bacteria. Most of it has been done in the laboratory of Wesleyan University by H. W. Conn and W. M. Esten. A considerable portion has been done in the laboratory at Storrs by W. A. Stocking and this paper is therefore the combined results of the two laboratories. The actual writing of the paper and the arrangement of the scheme of classification has been done by H. W. Conn who is therefore

responsible for the classification and arrangement of groups hereby adopted. It will be seen in the following pages that a large number of new forms have been added to those described in the previous paper and that not a few described previously have been excluded from the present list as insufficiently known. Our work in the last few years has added a large number of new forms to our list. These types which we have studied have been derived from a variety of sources. The larger part of them have been obtained from milk and milk products, either in the vicinity of Middletown or Storrs, and are therefore especially Connecticut forms. We have, however, received many cultures from elsewhere. Dr. Harding of the Geneva Station has kindly sent a large number; Harrison of Guelph, Canada, has sent us some; several have been sent by Marshall from Michigan; a large number were furnished us from the Board of Health Laboratory of New York City and separated from New York City milk which is obtained from a wide territory in the vicinity of that city; some have been sent from Dr. Weigmann of Germany; some from Switzerland by Freudenreich; some from Italy by Gorini; and a few isolated forms have come from other sources. The cultures that we have had for examination have thus come from a very wide territory and while by no means complete, they represent fairly the dairy forms in the parts of the civilized world where bacteria are studied. Of the dairy forms described in the following pages the large majority we have ourselves had the opportunity of studying in our laboratory. But in order to make this list of dairy forms as complete as possible we have in the following pages inserted with the types that we have ourselves studied, the descriptions of quite a number that we have not seen but which have been well described by others. This has been done, however, only when the published descriptions are fairly complete and are sufficient to make it possible to determine the relations of the types in question. There have been a large number of bacteria mentioned and partly described in literature in regard to which this is impossible. Many bacteria have been mentioned as occurring in dairy products, and many named, whose description is so meagre that it is absolutely impossible for anyone to recognize them. In the Manual of Swithenbank these names have been collected and the descriptions given.

But most of them are worse than useless at the present time, for no one would be able to identify the bacteria from these meagre descriptions or even to tell whether the bacteria described belong to one or another group of bacteria. In a few cases this is possible, and where we have been able to do so we have associated these forms with some of the groups that we have described more in detail below. But the value of the descriptions in earlier literature varies with the completeness of the description, and the descriptions of a majority of these earlier described bacteria are so meagre that they are *absolutely worthless*. When, therefore, a type of bacterium has been named from characters which will apply to a score or more different types there is nothing to do but neglect it entirely. Not even its name can be retained if the type cannot be recognized. We have therefore, left out of our list large numbers of these types upon the ground that they must hereafter be absolutely omitted from descriptions because of the impossibility of determining what they are. We have tried to include in our list all bacteria that have been sufficiently described to render their recognition fairly sure, but, of course, there may be some omissions.

In our recent work we have tried to include in our technical routine of description all of the characteristics usually adopted for the general description of bacteria. We have, however, not adopted the practice of determining the formation of indol or the reduction of nitrates. The reasons for this omission have been that the data in question have not seemed to us to have much significance in relation of dairy problems with which we have been particularly concerned. Since these data have not been determined in the laboratory routine they have, of course, not been included in the following descriptions. It will be noticed that with some of the forms described by us the description is not complete. This is especially true of some of the earlier descriptions of types which have not been found in abundance and have not reappeared in our later work. Many of our earlier described species, however, though incompletely described at the time, associate themselves so closely with the forms more recently studied that they are merged in groups, which we now recognize and of which we give a more complete description. A few forms, however, are still left with nothing

except the original description made several years ago, a description which may be too incomplete to be of very much value. These are in a few cases retained in the following pages, but only for species that possess very striking characteristics. For instance, *M. l. rubidus*, having the power of producing a brilliant red pigment, is so striking a type that we did not think it wise to omit it even though the description was based upon a single culture obtained several years ago and is more or less incomplete.

It will manifestly require many years before a complete knowledge of dairy bacteria can be obtained. While we have in the following pages described about one hundred and sixty types, we recognize that this is by no means the complete list of even common forms; but to complete the list will require many years of laborious study. When we recognize the extreme variability of bacteria types, especially in physiological characters upon which their classification may be partly based, it becomes evident that to reach an end of the description of dairy forms is almost an impossibility. Our recognized types, as will be shown, vary in all directions and run into each other by more or less complete intermediate links. Every new set of cultures which we obtain from even similar sources show variations in various properties connecting them more or less with other types. This has been forced upon us more and more, as the data we have collected has increased, until we have almost concluded that the task of arranging these forms into species or even groups is hopeless; for even at the very best these groups will show such wide internal variations as to connect them more or less completely with the closely associated forms. Before such groupings can be finally made an immense amount of work and many years' study must be given. But every attempt to formulate our ideas clears our conceptions, and hence it is thought that the present endeavor to arrange the dairy bacteria in a scheme of classification, even though of necessity incomplete and doubtless requiring later changes, will bring us nearer to a proper conception of their relation and help toward a real understanding of problems of bacteriology.

The question of species.—The question of *species* among bacteria is at present an insoluble puzzle. It has become manifest that it is quite impossible to carry over to the classification of

bacteria the conception of word species which zoölogists and botanists have developed in the last century. It has been recognized by the modern zoölogist that the early conception of a species, as something sharp and distinct, is bound to be modified as variations are recognized. If this is true in animals and higher plants, it is more emphatically true of bacteria. Indeed we must practically abandon any thought of using among bacteria the term species with a meaning which has any similarity to that which is used for the rest of the living world. The question as to whether physiological variations are sufficient to characterize a new species is one which we cannot now answer, but this would be involved in an attempt to determine species of bacteria. Into these questions we do not propose to enter at all and shall not make any endeavor to arrange bacteria descriptions in the form of species and genera. The term species, therefore, will not be used at all in the following classification.

As our data has been increasing, it has become more and more evident that the bacteria which we have been studying naturally fall into series of groups. This has been dimly recognized by bacteriologists for some years, the *B. coli* group, for example, being one that for many years has had a somewhat recognized position. As we have collected the dairy bacteria, we have been able to see such groups becoming more and more apparent. In such a group there is usually a somewhat central type, but from this the numerous cultures which may be obtained and compared with each other show variations in all directions. Inasmuch as our characters are chiefly physiological, the variations of physiological properties naturally produce an immense confusion in the attempt to satisfactorily arrange cultures in groups. By these variations our different groups are more or less connected with each other, even when the groups are founded upon clear, sharp, positive distinctions. For example, the power to liquefy gelatin has already been recognized as one of the most fundamental characters, and yet this power of liquefaction is manifestly subject to wide variations. As has been shown several times, organisms which have the power of liquefying gelatin may lose this power more or less completely, and hence it is perfectly clear that some groups which liquefy may perhaps be only physiological modifications of non-liquefying types. Among the cocci described

in the following pages it will be seen that there is a white liquefying and a white non-liquefying group. In other respects these types resemble each other so closely that we are inclined to believe that they must be regarded as representing the same form, but two physiological varieties, one having lost the liquefying power which the other still retains. Similar variability is especially true in regard to pigments. Our experience has convinced us that whereas some pigments, like brilliant reds and deep oranges and greens, are distinctive characteristics of groups, the pale yellow colors and the white pigments are so sure to run into each other by intermediate variations that they are of very little value in distinguishing types. In the following pages it will be seen that a white and a yellow type of coccus has been described and recognized as different groups, but the intermediate forms which we have found convince us that they are really practically the same thing with slight physiological variations. Even in the question of morphology, which is usually regarded as the most manifest criterion for distinguishing types, something of the same appears. The distinction between the short rods forms and the coccus forms is by no means a sharp one. Cultures which have been described in our own laboratory as short rods have been sent to other laboratories and been described as coccus forms. To eliminate the confusion arising in all of these ways is manifestly as yet impossible, but we have endeavored in the arrangement of groups given in the following pages to recognize the sharper distinctions and to state, where possible, the connections of the groups by intermediate forms which have been discovered.

In our studies, as involved in the following pages, we have endeavored to work upon and describe only such types as are usually found *in nature*. Cultural varieties are not generally included in our list. The work in our own laboratory and elsewhere has shown that by modifications of the culture conditions an endless series of modifications may be produced in the descendants of the same original stock culture. The power of producing pigment may be changed, the power of liquefying gelatin, the shape of the bacteria themselves may be quite modified by different culture methods. It does not fall within our purpose to include such cultural varieties. We are interested, in this paper, not in knowing through what variations

different stock cultures may be forced, by modifying conditions, but rather what are the physiological characters of the types that actually exist under the conditions of nature and which may be found in normal dairy products. Most of the types described in the following pages, therefore, *are actual cultures obtained from dairy materials*, and in no case do they represent modifications of such forms, except such modifications as naturally occur under the normal cultures in the laboratory. A few cultures sent us by others form an exception to this rule.

To our mind the aim of classification of such a group of bacteria at the present time should be as follows:

1. To recognize the *groups* of bacteria in the terms above used, and then to describe these groups in such a way that they may be with tolerable ease recognized by others working upon the same subject.

2. To recognize the kinds of variation possible within the groups. By this is meant the study of as many natural cultures of the members of the group as possible, noting what variations appear in the different cultures, as isolated from milk, and thus determining to what extent the group characters are modified in the different forms of bacteria as isolated from actual milk products.

3. To find, if possible, the natural limits of such groups. By this, of course, is meant to determine the limits within which the variations may occur, and yet the type in question may be legitimately regarded as belonging to the group in which it is placed. If no such limits could be found, naturally the whole question of classification of bacteria would be pretty nearly hopeless. It may be that as information accumulates, it will be found that all of these groups so run into each other as to make it impossible to logically separate them. This is, of course, what would be naturally assumed upon the general theory of evolution of types, but whether such is the case can only be determined after an immense amount of data has been accumulated. At the present time, with the data at hand, it seems to be possible to arrange these forms into fairly distinct groups which, though connected more or less with intermediate types, are nevertheless recognized with as much certainty as the different types of animals and plants may be recognized.

In determining these groups the primary question that arises, of course, is what characters shall be used to separate the groups. While all characteristics should, of course, be taken into account, some are clearly of more importance than others. There is among bacteriologists as yet no consensus of opinion as to what characters are of most importance for this purpose. It is, however, quite generally thought that morphological data are primary and that these should be the first points of distinction between these organisms. We are inclined to believe that this is true, but as intimated above, we have been forced to think that it is necessary to make certain modifications of this statement. The cocci and bacteria certainly run into each other in such a way that it is sometimes simply impossible to determine whether a culture should be called an extremely short bacterium or a coccus type. As already stated, the same culture will be described by one person as one and by another as the other of these two forms. Moreover, the classification of the spherical forms as usually accepted to-day into the streptococcus and micrococcus groups appears to be impracticable in many cases. We have found many forms of bacteria in which it is practically impossible to determine whether we are dealing with a coccus that divides in one plane only or in two planes. Moreover, in one or two cases we have clearly found a spherical form that multiplies for a long time by dividing in one plane, producing a long chain, which would be then naturally called a streptococcus, and then the whole series of spheres divided in the other plane, at once giving chains of pairs. This observation has been made once or twice in our own laboratory and has been confirmed by Winslow. Whether to call such a type a streptococcus or a micrococcus is evidently a problem. We have furthermore found in our study that many forms which are described as streptococci are identical in every character with others described as micrococci except this one point of the method of division. These facts have convinced us that this distinction of the micrococci and streptococci is an uncertain one, and we have not found it possible to follow it out with accuracy. We have therefore used this character as a secondary rather than a primary one in distinguishing types. The question of flagella present upon microorganisms has appeared to us to be of more importance than

some of the other morphological characters. We have in our classification, therefore, sharply separated the motile from the non-motile rods and the peritrichic from the monotrichic bacilli. In a few of our early described species in which flagella were not made out we have found it possible to group them from their other characters with later isolated cultures which are more carefully described.

The question of the liquefaction of gelatine has also been an open one, for the data at our command seem to suggest that here, too, we have a character that is somewhat variable. Some types show this property of liquefaction only after two or three weeks' growth, and we have considerable data to indicate that the power of liquefying may be completely lost; indeed, among the organisms isolated from milk we have occasionally found two that are identical in every respect except in this power of liquefaction, and organisms that have such peculiar character as, for instance, the power of producing a pink fluorescence, as to convince us that we are really dealing with the same organism, but one in which the property of liquefying gelatine is capable of being totally lost.

In the grouping of bacteria in our key we have used prominently the power of fermentation of sugars as a means of diagnosis. This characteristic is one which has become recognized recently as quite significant, and for the purpose of the study of the groups of the bacteria of milk, it is evidently one of exceptional importance. The fermenting power of sugar is closely related to the action of the organisms upon milk, and clearly from the standpoint of dairy bacteriology a grouping of bacteria with this as a basis is one of the most practically useful methods of grouping these organisms. But here, too, it appears to us that variations are common. Some of our groups contain organisms which apparently show considerable difference in their power of fermenting different sugars. It is common to separate in different groups any organisms which would ferment dextrose but not saccharose from one that would ferment the two sugars. As we have compared together the large numbers of cultures from various sources that we have made, we have found such wide variations in this power of fermenting sugar that we have been inclined to believe that here, too, we have a variable factor, and that whereas the general

power of fermenting sugar may be taken as a valuable and important criterion in separating groups, there may be variations among the members of this group in the kind of sugars they can ferment and the readiness with which they can carry on this action. At all events we believe that the variations in the power of fermenting sugar are only of value in separating closely allied varieties from each other, but quite insufficient to characterize different groups.

The production of pigment by bacteria is one of the characters frequently more striking than any other. The question of the value of this characteristic in separating organisms from each other has been much discussed. It has been many times shown that this power of producing pigment is capable of variation. It is certainly true that some organisms that are able to produce pigment under some conditions lose this power after cultivation. *B. rudensis*, for example, which, when first isolated, produced a brilliant red pigment, wholly lost this power in cultivation, and when the organism had reached my laboratory many months from its original source, it was a pure white Bacterium, showing all the other characteristics of the genus, but having lost its pigment-producing power. If the power of producing pigment is thus capable of variation, it indicates, of course, that it is not a criterion to separate types radically from each other. Nevertheless, in the general study of micro-organisms this is one of the characteristics which must be taken into consideration. Even though we recognize that some pigment-producing organisms may, under conditions of long cultivation in the laboratory, be converted into non-pigment-producing types, it is none the less important for us to recognize the pigment-production as a distinct characteristic of the organisms as found in milk productions.

For practical purposes it is a matter of less importance to know that a red pigment may cease to be developed after long cultivation in the laboratory than it is to recognize as a distinct type of dairy organisms a bacillus producing a red pigment. We have therefore used the pigment production as one of the characteristics for separating our groups. From our observations we have been inclined to think that red, orange, brown, and green pigments are commonly distinctively characteristic, that a lemon yellow color is also a character which remains

tolerably constant, but paler yellows are of far less significance. In our classification the color of yellow or yellowish cannot, therefore, be regarded as particularly important, and we are convinced that many of the varieties described as yellow are identical with others described as white. Where we have good reasons for believing this is the case, we have mentioned the fact in the following pages by cross references.

In our opinion the other characteristics commonly used for describing bacteria are less significant. The appearance of the colony in gelatine is subject to wide variations, and while sometimes it is useful, it cannot be relied upon as a rule as of very great importance. The growth on potato varies more or less widely with the nature of the potato, and so decided are these variations that we have ceased to place much confidence upon the characteristics here described. The growth in bouillon has appeared to us to be of less importance than some have thought, even the formation of a scum being somewhat variable in different cultures of the same organism.

The question of nomenclature is, of course, a puzzling one in dealing with a new group of organisms, whose inter-relations are as problematical as that among bacteria. Nevertheless, it is desirable that certain names should be given in our classification. In the following pages, we have adopted the following plan. We have named each of the general groups of organisms which we have recognized as more or less clearly marked types. The names that we have given to these are in all cases where possible names already applied to the chief members of the group. In many cases we cannot find among described bacteria any which agree closely enough to admit of identification, and in regard to many others, while there are among described types some which agree with ours as far as they go, the published descriptions are too incomplete to admit identification. In both of these cases we have given new names. In our names we have in practically all cases used the word *lactis* in the name. We are fully aware of the objections to using three names for a species, but in these cases the manifest advantage of indicating by the name the fact that the organisms are associated with and found in milk products is so great that we regard it as sufficient to overcome the disadvantage. We have used this method in all cases except a few well known organisms where it was manifestly unwise.

Underneath these groups we have tried to recognize the types of varieties which we have found and which are therefore liable to be isolated from any samples of milk, and for the present we have grouped these as varieties A, B, C, D, etc., under the general name of the group. In this way we recognize the general classification of bacteria, and at the same time obtain an impression of the variations that develop within the types themselves.

Method of Description.—In describing a long list of species of bacteria such as are included in the following pages, there are two different purposes to be considered, each of which would involve a different method of procedure. First, there is the question of *diagnosis*, which would call for such an arrangement of important characters as will enable other bacteriologists to identify forms which they may have in hand with those already described. There is, second, the need of such a complete description of the organisms in question, with *all* its other characters as will finally and definitely describe them for a permanent record. In accordance with which of these two purposes we have in mind the method of description would be varied.

In our own opinion at the present time the first of these two points is the more important. Until we know more about the general relations of bacteria, it is more important to have such a grouping of the types as will enable others to identify the cultures which they may have under observation with those already described. The more minute detailed description of species will undoubtedly of necessity come later. But when we recognize that such considerable variations of the same type are possible, and certainly do occur under cultural conditions, it becomes evident that the minute description of the physiological characters of the different cultures becomes of comparatively little value. If the types are not constant in all of these points, it is certainly of no great value, at least in the present state of bacteriological science, to describe the particular characteristics of a culture at any particular time, especially if it is true that when cultivated in the laboratory for six months, these characters may largely change. Hence we have concluded that with the present state of bacteriological science the more valuable form of classification will be one which will

select the salient features, and so far as possible those that are the least subject to variation, and so tabulate them as to make it feasible and convenient for other students to recognize the types in question and to identify them with any other form they may be studying. We have, therefore, in the following pages placed emphasis wholly upon the question of *brief diagnostic characters* and in arranging them in such a form that they can be easily utilized, rather than in a detailed description of species.

We have also learned from experience that unless the characteristics of species can be clearly and distinctly *tabulated*, it is almost a hopeless task for anyone to identify a new culture with one previously described. The methods of description that have been in vogue in the first decade of the study of bacteria have been to describe in somewhat verbose detail all sorts of minute characteristics, which later discovery has shown to be of little or no significance. These have been commonly arranged in no order and have never been tabulated. The result has been that it is almost impossible to identify any previously described type of bacteria. Consequently the bacteriological literature has seen a constant succession of new types described, and when these descriptions are compared with each other it becomes more and more evident that the same general type of bacterium has been described over and over again by different bacteriologists and given name after name. Undoubtedly some of our most common dairy organisms have been given a dozen or fifteen names, due to this unfortunate method of describing species by long details. We have endeavored, so far as possible, to correct this error in our classification, by excluding all unimportant data and keeping only what seemed to be the distinctive and more or less constant characters, and then to arrange these in such tabular form by methods already known so as to make it possible to use them conveniently.

We have arranged our classification as follows: We have first inserted a detailed description of the different bacteria which we recognize under different names. Instead of attempting however, to describe these to any great length, as would be necessary if all of the characters were filled out which are demanded by the description blanks of the American Society of

Bacteriologists, we have endeavored to insert only the salient characters. It has appeared to us that the numerous details only confuse one in an attempt to identify and classify bacteria. When it is so evident that these physiological characters, which are largely the basis of these long descriptions, are capable of such great modification by culture, when it is evident that the cultures of bacteria which one obtains are likely to come from a great variety of sources and therefore to have been subject to a large variety of different conditions, it is evident that we may expect an almost endless variation in the physiological characters of the different cultures. If we do not identify two cultures of bacteria as the same until we find that they agree *exactly in all* of the long series of characters given in the society blanks, we shall practically never identify any two types of bacteria as the same. It has seemed to us that this is an absurdity and that the recognition of the relations of bacteria will be advanced by omitting insignificant details, concentrating our attention upon the more important characters. For this reason we have in these descriptions omitted much of detail and have only given such points of description as have seemed to be most salient.

Following the detailed descriptions we have given analytical keys and tables covering all the types. We recognize the fact that the bacteria of milk may be grouped in three general groups, the *Coccaceae*, the *Bacteriaciae*, and *Bacilliariciae*. These groups are morphological ones, and while, as has already been pointed out, we are convinced that to a certain extent they run into each other and cannot be sharply distinguished, they do represent fairly well marked groups. Under each of these heads we have given an analytical key, in which the important characters are used for purposes of diagnosis. By means of this key it is possible to trace readily to its group or to its allies any type of bacterium of which we have a tolerably complete description. These analytical keys are given for each of the great groups of bacteria. Following these analytical keys we have given finally a tabulated key of all of the important characters of the different species. In the preparation of this key we have made use of the plan adopted by the American Society of Bacteriologists, selecting the important characters which can be indicated by positive

and negative signs. This plan, advanced some years ago by Fuller, has proved useful, and inasmuch as it has been provisionally adopted by the American Society, we have made use of it in the tables of our key. In our own opinion the plan advanced by Gage and Phelps in using numbers that have certain arbitrary meanings is far more satisfactory and far more usable than this plan which the American Society has adopted; but it is better to have uniformity in the matter even at the expense of some loss, and we have therefore adopted the plan of the American Society. All of our species are arranged in tables in this way, the tables being so grouped that organisms which are most closely related to each other come in proximity. With this plan it is only necessary in order to identify the relations of a new type of bacterium, to fill out on one of the cards prepared by the American Society, the blanks left for the insertion of the characters, and then to place this blank upon the table in the following pages and running it up and down the page until there is found one organism with which the plus and minus signs practically agree. When this is found it is sure that the allies of the species under consideration have been identified, though it may not agree in all details. In this table we have also used the group numbers as directed by the American Society of Bacteriologists, this group number being another important aid in identifying a culture and placing it among its allies.

In a number of cases we have found that what we believed to be the same organism comes under two different heads in our classification; for instance, a culture has been described as a Bacterium and another one as a Coccus, and yet when carefully studied out in all other respects they are found to be the same. Under these circumstances we have been uncertain as to where it should be classified and we have therefore placed it under both divisions of Coccacece and Bacteriaciae. The same thing has occurred occasionally with organisms that liquefy or do not liquefy gelatine. In all such cases cross references are inserted to indicate these probable relationships.

It should be finally stated that the forms which we recognize in the following pages which we name must be regarded as groups and not species. This is not at all material, inasmuch as we have no conception whether the term species has any

meaning whatsoever among bacteria. Our names, therefore, refer to groups under which there are in some cases many sub-varieties, in other cases few and in some cases no sub-varieties. From the standpoint of practical dairying the sub-varieties are sometimes of more significance than the general type. For example, under the head of *Bacterium lactis acidi* there are certainly a number of varieties differing in respects which are of extreme importance to the dairyman. They differ in the amount of acid they produce and in their power of curdling milk. So, too, under the head of *Bacterium lactis aerogenes* we have clearly a group of organisms differing in many important characters. Among these characters there is wide difference in the extent of the gas production; some cultures producing only a small amount of gas, others producing gas in prodigious quantities. While these variations in the amount of gas cannot, in our opinion, be regarded as points by which the group should be separated from each other in a scheme of classification, they are of the highest importance to the dairyman. The variety which produces a small amount of gas would be consistent with the best dairy products, while the presence of the other variety would totally ruin a lot of butter and more surely ruin a lot of cheese. These sub-varieties, in short, are of extreme importance to dairymen, and the careful study of these varieties is a problem which should be considered carefully in the future; but in a general classification of bacteria it is, in our opinion, at present quite impossible to recognize all of these types by name, and our present plan is, therefore, only to group them as varieties under the general group name.

METHOD OF STUDY AND DESCRIPTION.

A few words are needed as to the method of obtaining the data tabulated in our descriptions. The *isolation* of the bacteria is usually accomplished by the use of litmus gelatine. The preparation of this litmus gelatine has been described in a former publication. (Bacteria in Milk and its Products, P. Blakistons Sons.) This has been used because our experience has shown that it gives a better differentiation of colonies than other solid media. After isolation the cultures are *purified* by the ordinary

method of replating, and, after purification, they are inoculated, upon *agar streaks*. After about two days' growth on agar they are inoculated into the various other culture media.

The *morphology* of the various organisms was determined from fresh agar streak cultures although, to determine the formation of spores, it was sometimes necessary to use older cultures. To determine the *motility* we have usually used an ordinary bouillon culture of 12-24 hours' growth. We have found that a careful study of a hanging drop of such a bouillon culture is most satisfactory for this purpose. To determine the presence of *flagella* we proceeded as follows: from an actively growing bouillon culture a drop was removed with a platinum loop and spread thinly over the surface of solidified agar. This was then incubated at 37° for 12 hours. A small quantity was then removed, diluted in three successive drops of sterilize water and stained by the well known Loeffler method.

The culture media we have used have been those ordinarily employed. Our bouillon, gelatine and agar have been made with Liebig's beef extract instead of chopped beef, because of greater convenience and uniformity. The *fermentation tube test* was made with dextrose, lactose and saccharose, 1 per cent. of these sugars being added to ordinary bouillon. In all the cultures tested by us in the last five years we have used all three sugars. The *milk* which we have used has in all cases been skimmed milk, sterilized by boiling for 10-15 minutes on three successive days. *Potato cultures* have been made by cutting plugs from large clean potatoes, slicing them once obliquely, and then soaking them in running water over night. After this they were placed in tubes and sterilized in an autoclave.

In general the terms which we have used in our descriptions have been those suggested by Chester and adopted by The American Society of Bacteriologists. In stating whether or not an organism produces *acidity* we refer to the production of acidity in dextrose bouillon. In some cases, as will be seen, organisms produce acidity in lactose but not in dextrose; but these are rare. The detection of acidity has been made by means of carefully prepared litmus paper. This paper we have prepared ourselves from neutral litmus. The test for acidity has been made in about two days, and also later. This method has been adopted, both for the fermentation tubes and for milk. In determining

the *action upon milk* we have always used both the temperature of 20° and 37°. In our descriptions in the following pages we have not referred to the action of these two temperatures, except in cases where it was different at the two temperatures. It will be understood, then, that the actions given as taking place in milk occur at both temperatures unless otherwise specified, although usually, of course, more rapidly at the higher temperature. The *digestion* of milk has been determined by eye only.

We have hitherto done no work upon strictly *anaerobic* bacteria. Most of the forms which we have described have been aerobes, although some grow more readily if they do not have too abundant a supply of oxygen. The question of their relation to oxygen we have determined from their surface growth on various media, their growth in the closed arms of the fermentation tubes, and also from their growth under a mica plate which we have always made and frequently found useful, although we have not tabulated it in the following pages.

DETAILED DESCRIPTION OF TYPES.

A. NON-LIQUEFYING COCCI.—STREPTOCOCCI AND MICROCOCCI.

I. Types that do not produce acid.

M. lactis rosaceus n. s. *A pink Micrococcus.* This organism, orginally found in 1903, has been found twice since, in milk, in this vicinity. All cultures agree in essential particulars.

Morphology.—Size, .8μ in diameter. Stains by the Gram method.

Gelatine colony.—Surface colony reaches the size of 1 mm., with a nucleus and a light outer zone. The color is pink. On *litmus gelatine* it produces a bluish colony which is not acid.

Gelatine stab.—A needle growth and a spreading pink surface.

Agar streak.—A luxuriant pink growth.

Fermentation tubes.—No acid nor gas is produced in any sugar bouillon, and no growth in closed arm.

Bouillon.—A sediment and a slight turbidity, but no pellicle.

Milk.—Rendered slightly acid and shows a slight pinkish sediment. It becomes somewhat slimy.

Potato.—A very luxuriant, thick, moist growth of a pink color.

Grows at both 20° and 37°. Aerobic.

M. lactis citreus B n. s. *A yellow, non-acid Coccus.* (Perhaps=*M. citrinus Migula*). The similarity of this culture to our yellow liquefying coccus leads us to think that they are perhaps the same and hence the use of the same name. (See *M. lactis citreus A*, p. 118.) This organism has been found but once in milk in Middletown. Its characters are as follows:

Morphology.—Size, .8μ. No chains produced. Stains by the Gram method.

Gelatine colony.—A distinctly round, thin, yellow surface colony, which becomes about 1 mm. in size. Not characteristic.

Gelatine stab.—A good needle growth and a moderately luxuriant surface growth, of a yellow color.

Agar streak.—A luxuriant, yellow growth.

Fermentation tubes.—There is no production of acid or gas in any sugar bouillon, and no growth in closed arm.

Bouillon.—An abundant sediment and turbidity, and a thin pellicle on the surface.

Milk.—At both 20° and 37° the milk is rendered acid, but it is not curdled or otherwise affected. The acidity is very slight.

Potato.—An abundant, canary-yellow growth, and the potato is discolored.

Grows well at both 20° and 37°. Aerobic.

M. lactis flavus n. s. *An orange, non-acid Micrococcus.*

Morphology.—A micrococcus. Size, .5μ–.8μ. Stains by the Gram method.

Gelatine colony.—A round, smooth, thick, homogeneous, orange-colored surface colony.

Gelatine stab.—A good needle and surface growth, with an orange color.

Agar streak.—Luxuriant, moist, smooth, of an orange to a red-brown color.

Fermentation tubes.—No acidity or gas in any sugar bouillon. Dextrose and lactose may be rendered alkaline. No growth in the closed arm.

Bouillon.—A sediment, a turbidity, and a pellicle; or the turbidity and pellicle may be wanting, the latter characteristic belonging to a second culture isolated at a different time.

Milk.—Is rendered acid both at 20° and 37°, but no other change is produced, except a slight yellow color in some cases.

Potato.—Moderate to luxuriant, moist, smooth, red-brown to orange.

Grows at 20° and 37°. Aerobic.

We have found this organism several times. The different cultures differ, however, in small points. The chief lines of difference were the following: In color it ranges from orange to bright yellow. In two cultures the gelatine colony was white rather than yellow, and in these same two cultures milk was not rendered acid. One culture curled milk, acid. One culture grew in the closed arm of the fermentation tube, while the others did not. We are not inclined to think these differences sufficient to separate them as varieties.

Apparently this is identical with *Micrococcus D.* of Barthel, and perhaps with *M. aurantiacus* Cohn.

M. lactis viscosus C n. s. *A slimy milk Micrococcus.* This culture was sent us by Harrison and was isolated by him from Pasteurized milk. We have not found it ourselves. Its failure to make milk acid and its dark colored growth on potato seem to distinguish it from any other slimy milk micrococci. Hence we call it variety B. (See p. 114). The characters are as follows:

Morphology.—A micrococcus. Size, .8μ–.9μ. Gram stain positive.

Gelatine colony.—A thick, round, smooth, white colony. In old cultures the gelatine is turned green. On *litmus gelatine* the colony is coarse, granular and nucleated. The surface growth is rather transparent. Below the surface it is opaque and brownish.

Gelatine stab.—A vigorous needle and surface growth.

Agar streak.—Moderately thin, spreading, white.

Fermentation tubes.—Neither of the sugar bouillons is rendered acid, nor is there any gas produced, nor growth in the closed arm.

Bouillon.—A sediment and turbidity, but no pellicle.

Milk.—No change except the production of a decided sliminess.

Potato.—A luxuriant, thick growth of a slaty-gray color, turning to blue or black, and old cultures to an olive-green. The potato itself is discolored.

It grows well at both 20° and 37°. Aerobic.

The organisms that produce slimy milk are numerous. They do not by any means form a class by themselves, for this property of rendering milk slimy seems to be found scattered widely among bacteria. Apparently the type that most commonly produces trouble in dairies is a Bacterium. The following organisms have been described as causing sliminess, some of which are included in our list and others omitted as insufficiently described: *M. viscosus* Bechamp, *Actinobacter du lait visqueux* Duclaux, *Actinobacter polymorphus* Duclaux, *B. mesentericus vulgatus* Flügge, *M. mucilaginosus Migula* Migula, *B. lactis pituitosi* Loeffler, *Strep. Hollandicus* Weigmann, *Bact. lactis longi* Troili-Petterson, *B. Guillebeau c.* Freudenreich, *Bact. Hessii* Guillebeau, *M. Freudenreichii* Guillebeau, *Carpho. coccus pituitoparus* Hohl, *Coccus lactis viscosi* Grüber, *B. lacto rubifaciens* Grüber, *Bact. lactis acidi* Leichmann, *Bact. aerogenes* Escherich, *B. Harrisonii*, *M. viscosus A*, and some others. This list includes almost every type of bacteria, so that the characteristic of slimy milk cannot be taken as forming a group mark.

M. lactis arborescens.—This was described in our former report and has been found twice since.

Morphology.—A micrococcus. Size, .7μ in diameter.

Gelatine colony.—A myceloid colony about 1 mm. in diameter. Sometimes it is smooth.

Gelatine stab.—An arborescent needle growth and a surface growth.

Agar streak.—A luxuriant, white, smooth moist growth.

Fermentation tubes.—Not determined, but doubtless neither acidity nor gas.

Bouillon.—A turbidity, sediment and a tenacious scum.

Milk.—No action or a very slight alkalinity.

Potato.—A spreading, brownish growth, not very luxuriant.

Grows at 20° and 37°. Aerobic.

Galactococcus versicolor Lux. *A white non-acid coccus.* One of the most common types of milk organisms proves to be a small white coccus that does not produce acid and without any very marked characters. There are a large number of these which, although showing some variations, are so much alike that we regard them as forming a single type. They are extremely common in milk and are certainly found in the udder very commonly. We have adopted the name first given by Lux as fairly distinctive, although we think it would be better to use the name *Streptococcus versicolor.* We can recognize two types although no sharp line can be drawn between them.

Morphology.—A streptococcus. Size, .5μ–1.5μ. Never more than three or four joined together. It commonly stains by the Gram method.

Gelatine colony.—Spreads slightly over the surface, white, yellowish or brownish, lobed or round or rather thin. The colony is not characteristic.

Gelatine stab.—An abundant needle and a surface growth.

Agar streak.—White to yellowish, moist, not luxuriant.

Fermentation tubes.—No acidity in any sugar bouillon; there is no gas or closed arm growth.

Bouillon.—A sediment and turbidity but no pellicle.

Milk.—Usually no action, although a few cultures show a slight acidity.

Potato.—Very scanty, grey-white, or sometimes no growth.

Grows at both 20° and 37°. Aerobic.

Variations from the above are shown in color, from a white to a yellowish; in the formulation of a pellicle in one culture; and in the failure to stain by the Gram method.

Variety A.—We recognize as a distinct variety one form that grows luxuriantly on potato and has a less tendency to form a yellowish pigment. This type has also a slight tendency to produce an acidity in milk, in this respect agreeing with *M. candius* of Barthel, which is probably the same. Variety A is equally common with the type described.

One culture which would naturally belong here shows relations to *M. lactis albus* in that it digests milk, but does not liquefy gelatine. Its characters are as follows:

Variety B. Digesting milk without liquefying gelatine.

Morphology.—A micrococcus. Size, .6μ. The Gram stain is negative.

Gelatine colony.—Very small, yellowish, surface colonies, smooth, convex, entire, moist.

Gelatine stab.—A needle growth and a convex surface.

Agar streak.—Filiform, raised, smooth, transparent, moist, luxuriant. In some cases wrinkled.

Fermentation tubes.—No acidity or gas in any bouillon. Usually no closed arm growth, but one culture showed growth in closed arm.

Bouillon.—A sediment and turbidity; a pellicle sometimes forms and sometimes not.

Milk.—Becomes alkaline and digests. This digestion becomes complete in three weeks, and is unusual since the organism does not liquefy gelatine.

Potato.—Luxuriant, filiform, capitate, cream color. Potato not discolored.

Grows at 20° and 37°. Aerobic.

The description of this Coccus appeared to us to agree closely with that of *Streptococcus pyogenes.* To see how closely they agree, we obtained a culture of the latter from the bacteriological laboratory at Yale Medical School, and compared it with our cultures side by side. In all cultural characters we found that the two agreed so closely as to be indistinguishable. Whether this indicates that they are identical we would not at present determine, but the identity in cultural characters of this common pathogenic Coccus and this most common dairy organism is at least suggestive. In fresh milk this type is probably the most common of all dairy bacteria.

II. Types that produce acid in dextrose or other sugars.

S. lactis fulvus n. s. *A brownish-red Streptococcus.* This was obtained once directly from the udder and once from city milk. Another culture was obtained from stable dust which agree in all points except those indicated in brackets.

Morphology.—A streptococcus. Size, .7μ. Gram stain is positive.

Gelatine colony.—Small and dense, 5 mm. in diameter, rather thick, round, white. The colony in litmus gelatine is acid. [Brownish-pink to orange.]

Gelatine stab.—A needle growth and a thin surface growth.

Agar streak.—Luxuriant, thick, moist, translucent, reddish-brown [orange-yellow].

Fermentation tubes.—All three sugar bouillons rendered acid; there is no gas or closed arm growth.

Bouillon.—A sediment, turbidity, but no pellicle. [No turbidity.]

Milk.—Is acid and curdles.

Potato.—Luxuriant, brown.

Grows at 20° and 37°. Aerobic.

One culture obtained from New York milk shows some rather striking characters, and we recognize it as a separate variety as follows:

Variety A.—This agrees with the above except in the following: Size, 1.2μ–1.4μ. Gram stain negative. Gelatine colony ringed and irregular, showing acid in litmus gelatine. Bouillon with a pellicle. Milk, curdled acid at 37° only. Potato has luxuriant growth and is discolored.

M. lactis aureus n. s. Many different cultures of *yellow, acid Cocci* have been found in this vicinity, from Canada and New York. They are found in milk, in cheese, in butter, and in stable dust. Although they do not liquefy gelatine, we are confident that they are to be looked upon as non-liquefying forms of *Staph. pyogenes aureus.* (See p. 121.) The general description is as follows:

Morphology.—A micrococcus. Size, .5μ–1.2μ. Gram stain positive.

Gelatine colony.—Round, moderately thick, smooth, translucent colonies, of a lemon-yellow color. *Litmus gelatine* is acid.

Gelatine stab.—A needle growth and a yellow surface growth.

Agar streak.—Luxuriant, moderately thick, smooth, translucent, yellow.

Fermentation tubes.—All sugar bouillons are rendered acid, but there is no gas. Occasionaly there is growth in the closed arm.

Bouillon.—A sediment and turbidity, and rarely pellicle.

Milk.—Rendered acid and usually does not curdle. Some cultures, however, curdle milk after several days at 37°. Milk may be rendered yellowish.

Potato.—Usually a moderately thick, yellow growth, with the potato discolored.

Grows better at 37° than at 20°. Facultative anaerobic.

Among the many cultures which we have studied, variations are found in the following points: Size, from .5μ–1.2μ. Litmus colony is sometimes acid and sometimes not. Color varies from lemon-yellow to pale-yellow. In a few cases there has been closed arm growths in the dextrose, and sometimes in lactose. In two cultures a pellicle formed on bouillon. Milk always acid but

only about half of our cultures curdle it. Potato varies from scanty or no growth to luxuriant. We do not regard these variations as sufficient to warrant us in distinguishing them under different names.

S. lactis aureus n. s. *An orange red Streptococcus.* This organism is apparently sufficiently different from the last to be separately named. It was found in a Camembert cheese sent from France. Several varieties occurred all together in the same cheese and they are, doubtless, physiological varieties of the same organism.

Morphology.—A streptococcus. Size, 1μ–1.2μ. Gram stain positive.

Gelatine colony.—A round, thick, rough, opaque, surface colony, of a creamy-white color. On litmus gelatine it is dense and not acid, with an irregular edge. One culture was thin.

Gelatine stab.—A needle growth and a raised surface growth; orange.

Agar streak.—A luxuriant, rough, orange-yellowish to greenish-yellowish color; sometimes dull and wrinkled.

Fermentation tubes.—All sugar solutions are rendered acid, but there is no closed arm growth nor gas.

Bouillon.—A sediment and a turbidity are produced, and, after several days, a pellicle.

Milk.—After some days rendered acid and curdled. Some of the cultures did not produce acid and did not curdle; a slightly sour odor.

Potato.—A thick, rough, opaque, yellow, luxuriant growth; potato may be discolored.

Grows at 20° and 37°. Aerobic.

We have found several white coccus forms that produce *slimy milk.* The differences between them are considerable, although it may be that they are all variations of the same type. At present we recognize three.

S. lactis viscosus n. s.

Morphology.—A streptococcus. Size, .8μ–.9μ. The Gram stain is negative.

Gelatine colony.—A shiny, pale-yellow, round or lobate colony, 1 to 2 mm. in diameter. It is commonly viscous.

Gelatine stab.—A needle growth and a surface growth, producing a nail culture.

Agar streak.—An irregular lobate surface growth, quite luxuriant, viscous.

Fermentation tubes.—All three sugar bouillons become acid and there is growth in the closed arm, but no gas is produced.

Bouillon.—A sediment and a turbidity, and also a pellicle.

Milk.—Rendered acid and curdled after three or four days. The milk becomes very slimy.

Potato.—A luxuriant, dull, paste-like growth, of a gray to a yellowish color.

Grows at both 20° and 37°. Facultative anaerobic.

This description is from the slimy milk organism of group V. as given by Harrison. We have found an organism at Storrs which is apparently the same, and which we had previously named *M. lactis viscosus.* We will call this a distinct variety, and it differs from the above described in the following points:

Variety A.—The agar growth is scanty and not viscous. No pellicle is formed on bouillon. Growth on potato is luxuriant and the potato is discolored.

To this same group apparently belongs *M. Freudenreichii*, as well as can be determined by the incomplete descriptions given.

Reference must also be made to *M. lactis viscosus B.*, differing from either of those described, so as to be located elsewhere in our scheme. (See p. 109.)

The white cocci which produce *acid and no slime* are very numerous and their separation into groups is uncertain. We have tried to divide them into several types but the divisions between them are not satisfactory. Each of the groups shows variations, and it may be better to unite them altogether. For the present, however, we recognize the following divisions, based primarily upon their action on sugar and the abundance of their surface growth.

S. lacticus Kruse. This includes the smaller acid cocci with a scanty surface growth. This type is very closely related to, if not identical with, *Bact. lactis acidi*. The organism that commonly causes the souring of milk shows some variation in its morphological structure. It is sometimes clearly a short coccus form, while in other cases it is decidedly more elongated. In cultures, too, similar variations have been found. It commonly appears as a short rod, clearly longer than broad, and as such has been usually described as a Bacterium and named *Bact. lactis acidi* by Leichmann. By this name it is commonly referred to in literature. But cultures of *Bact. lactis acidi* when grown in lactose bouillon frequently, at least, appear as streptococci, and Kruse (Cent. f. Bac. u. Par. I., XXXIV., p. 737, 1903), and Heinemann (Cent. f. Bac. u. Par. II., XVI,, p. 538, 1906), have recently insisted that there is no such thing as *Bact. lactis acidi*, all of the organisms which have been so named being really cocci, which should be called *S. lacticus*. Upon this point we will at present express no opinion beyond the statement that the organisms as found in souring milk are sometimes streptococci and sometimes clearly longer than broad, and hence would be naturally classed as Bacterium. We regard it better at present, therefore, to retain the name *Bact. lactis acidi* for the milk type as it commonly appears, and to recognize the streptococcus form independently under the name given by Kraus. It has the following characters:

Morphology.—A streptococcus with commonly short, but sometimes long, chains. Size, .5μ–1μ. Gram stain positive.

Gelatine colony.—Extremely minute, white colonies, occasionally slightly yellowish, rough and dense. In *litmus gelatine* the colonies are always acid. The surface growth is always slight and usually absent entirely, and it grows better under a mica plate. Sometimes the colonies in litmus gelatine show minute spines on their edge.

Gelatine stab.—A moderate needle growth but no surface.

Agar streak.—The growth is hardly visible, but when it occurs is the faintest transparent film.

Fermentation tubes.—All three types of sugar are rendered acid and there is commonly a growth in the closed arm. No gas is produced.

Bouillon.—Growth is extremely slight and sometimes invisible. A slight sediment and turbidity may be produced.

Milk.—Rendered acid and curdled promptly, producing a typical, smooth, acid curd.

Potato.—The growth is usually invisible, but sometimes a scanty surface film may be seen.

This streptococcus is very common and in some specimens of soured milk comprises ninety-nine per cent. of all the Bacteria present. It has been found frequently in the milk in Middletown, in Storrs, in New York City, and elsewhere. Where it occurs it is commonly the cause of the souring of milk, but it is not so common as the elongated form which we have classified as *Bact. lactis acidi.*

The white cocci that produce *acid but no slime* are very numerous and their separation into groups is uncertain. We have divided them into six groups, but the distinctions between them are not satisfactory. Each of the groups has slight variations and it may be that some of them would be better united together. For the present, however, we recognize the following, dividing them first according to their action on various sugars, and secondly by the abundance of surface growth produced on media.

S. lacticus I. The essential character of this type is the production of acidity in dextrose but not in other sugars.

Morphology.—A streptococcus in pairs or short chains. Size, .6μ–1.2μ. The Gram stain is positive.

Gelatine colony.—This is not characteristic. It is round, white to yellowish and spreads over the surface, forming a colony 1 mm. in diameter.

Gelatine stab.—A needle growth and a surface growth.

Agar streak.—Moderately abundant, white.

Fermentation tubes.—Dextrose bouillon is rendered acid, but no gas is produced and no acidity in other bouillons.

Bouillon.—A sediment and turbidity and sometimes a pellicle.

Milk.—Becomes acid, but is not curdled, and no other change is noticed.

Potato.—Growth very slight or wanting.

Four cultures of this group have been studied—two derived from milk fresh from the udder, one from the dust of the stable, and one from cheese. They differ slightly, as follows:

Variety A.—This culture, from the udder, produces no turbidity, but a slight pellicle in bouillon.

Variety B.—From the udder. Produces turbidity and no pellicle in bouillon and does not make milk acid.

Variety C.—From stable dust. Has a negative Gram stain, a turbidity and a pellicle in bouillon, and milk is not acid.

Variety D.—From cheese. Shows a turbidity and a pellicle in bouillon; milk is acid, and there is a luxuriant potato growth.

S. lacticus II.—This produces acid in lactose and saccharose but not in dextrose. Its other points of difference are as follows: Gram stain is negative; the gelatine colony is very small and transparent; no pellicle is ever formed on bouillon; there is no action on milk and there is an abundant potato growth.

S. lacticus III.—This shows a pellicle on bouillon; the milk is usually acid and occasionally curdled, but in some cases shows no trace of acid to litmus paper. The potato growth is usually scanty or wanting, though sometimes more luxuriant.

M. lactis acidi.—This name includes the smaller acid-producing cocci that have a luxuriant surface growth on various media. There are very many of them. Probably *M. candicans* of Flügge belongs here. Their general characters are as follows:

Morphology.—A micrococcus. Size, .5μ–1.2μ. Gram stain is positive.

Gelatine colony.—Not characteristic. The colonies are round, thin, smooth, rather opaque and white in color. On *litmus gelatine* no acid is produced.

Gelatine stab.—Needle growth and surface growth.

Agar streak.—A moderate, white, smooth growth, which is sometimes rough.

Fermentation tubes.—All fermentation tubes show an acid production, but no gas and no growth in closed arm.

Bouillon.—A sediment and turbidity, but no pellicle.

Milk.—Sometimes acid and sometimes not acid. Usually not curdled, though some cultures curdle the milk by acid production. Occasionally a slightly sour odor.

Potato.—The growth is usually scanty and sometimes absent. It is whitish; not characteristic.

Grows at 20° and 37°. Aerobic.

This is the most common of the milk cocci. It is found almost constantly in common fresh milk, both here and elsewhere, where we have had an opportunity of studying it. It is clearly very similar to *S. lactis acidi III.*, the primary difference being in the amount of surface growth. We have studied very many different cultures of this type and naturally found many variations. The most noticeable points of variation are as follows:

Size, from .5μ–1.2μ. Gelatine stab in two cases showed no surface growth; colony on gelatine varies much in thickness and is sometimes slightly yellowish; the litmus gelatine colony is occasionally acid; the growth on agar varies much in abundance, but is always more than in the lactic type.

M. lactis gigas n. s.

Morphology.—A very large coccus. Size, 1.5μ. Gram stain is positive. No chains.

Gelatine colony.—A round, thick, smooth, homogeneous, entire translucent, cream-white colony.

Gelatine stab.—A needle growth is produced but no surface.

Agar streak.—Growth is scanty, beaded, translucent and white.

Fermentation tubes.—All three sugar bouillons are rendered acid but there is no growth in the closed arm and no gas.

Bouillon.—A sediment but no turbidity and no pellicle.

Milk.—Becomes very slightly acid, sufficiently to curdle the milk in about four weeks.

Potato.—No growth.

Grows at 20° and 37°. Aerobic or facultative anaerobic.

This coccus is characterized by its very large size and has been found several times by us in Middletown and Storrs. It was first isolated in 1896.

B. LIQUEFYING COCCI.—STREPTOCOCCI AND MICROCOCCI.

I. No acidity produced in dextrose or other sugars.

M. lactis erythrogenes Grotenfelt n. s. *A pink, fluorescent coccus.* Several specimens of a micrococcus giving a pink fluorescence have been found. We have given them the above name, although in our cultures they do not render milk red. As studied in our laboratary their characters are as follows:

Morphology.—Size, .8μ. No chains.

Gelatine colony.—A smooth, flat colony, .5 mm. in diameter in four days, which later sinks into a shallow pit.

Gelatine stab.—A white needle growth, with a slow liquefaction and a dense scum, stratiform.

Agar streak.—A luxuriant, white to yellowish growth, with a pink fluorescence.

Fermentation tubes. No acidity and no gas.

Bouillon.—A sediment and a turbidity formed, but no pellicle.

Milk.—Rendered slightly acid and digested into a semi-transparent yellowish liquid; not curdled.

Potato.—A luxuriant, yellow, moist growth.

Grows at both 20° and 37°. Aerobic.

This organism is clearly allied to *B. lactis erythrogenes* if it is not identical with it.

M. lactis rubidus n. s. *A red coccus.* This organism has not been found since its previous description. It resembles *M. cinnabarius* of Flügge, differing from it in the points shown in brackets. The following is the description of our organism as given in our previous publication:

Morphology.—Size, 1μ. No chains.

Gelatine colony.—A rapidly liquefying, red colony. Some of the colonies on the same plate are not red. [Dull red color.]

Gelatine stab.—Infundibuliform growth, which later liquefies completely, forming a red liquid. [Liquefaction only partial.]

Agar streak.—A thick, moist, blood-red growth. [Yellowish brick-red.]

Bouillon.—A sediment and turbidity, but no pellicle; the sediment is pinkish.

Milk.—No change in the action. Old cultures show a digestion with a pinkish surface.

Potato.—A very luxuriant, blood-red growth [yellow to red] spreading over the potato.

Grows at both 20° and 37°. Produces no pigment at the latter temperature. Aerobic.

While this organism is quite similar to Flügge, his is too insufficiently described to be sure of the identity.

M. lactis citronus n. s. *An orange-colored, liquefying Micrococcus.* This was found in the red slime on Camembert cheese.

Morphology.—Size, .8μ–.9μ. Gram stain irregular; no chains.

Gelatine colony.—A yellowish, slowly-liquefying colony, with a clear liquid. *Litmus gelatine* is reddish-brown in color.

Gelatine stab.—Liquefaction begins in four days and is never complete. Stratiform.

Agar streak.—A spreading, thick, smooth growth of an orange color, somewhat viscous.

Fermentation tubes.—No acidity, no gas, no closed arm growth in any sugar bouillon.

Bouillon.—A sediment, turbidity and a pellicle.

Milk.—No action on milk.

Potato.—Luxuriant, thick, smooth, orange-brown.

Grows at 37°. Aerobic.

S. lactis citreus I. n. s. *A lemon-yellow, liquefying Streptococcus.*

Morphology.—A streptococcus. Size, .6μ–1μ. Gram stain positive.

Gelatine colony.—A small colony, with clear liquid and slow liquefaction. Not characteristic.

Gelatine Stab.—A slow liquefier with stratiform liquefaction.

Agar streak.—A luxuriant, thin, lemon-yellow growth.

Fermentation tubes.—No acidity, no gas, no growth in closed arm in any sugar bouillon.

Bouillon.—A turbidity, a sediment, and a pellicle.

Milk.—Slightly alkaline, or no change in reaction, and a slight digestion.

Potato.—Luxuriant, moderately thick, lemon-yellow.

Grows best at 20°; less luxuriantly at 37°. Aerobic.

The culture from which this was taken was from the centre of a cheese.

Variety A.—A second culture from the same cheese near the surface, differed in producing an acidity in dextrose and saccharose, and no pellicle nor digestion of milk.

Variety B.—From Storrs; found in milk. Did not liquefy the gelatine plate, but produced a thin, flat colony, 2.5 mm. in diameter.

Variety C.—From milk in Middletown. Produced a slowly-liquefying, granular colony, 2–3 mm. in diameter; a wrinkled growth on agar; a pellicle upon bouillon, and a digestion of milk.

Variety D.—Showed no potato growth, but an acidity in milk, although the milk digested.

Variety E.—From cheese. Showed no potato growth and a very slow liquefaction, with no milk digestion. We have no hesitation in regarding them all as belonging to the same type.

S. lactis Rogeri n. s. *A lemon-yellow, liquefying Streptococcus.*

Morphology.—Size, .7μ–1μ. Gram stain irregular; chains produced.

Gelatine colony.—A slow liquefaction, with a thin, transparent, granular colony, at first white. *Litmus gelatine* is intensely alkaline, with a spindle-shaped colony.

Gelatine stab.—A needle growth and a stratiform liquefaction beginning in one day.

Agar streak.—A luxuriant, thick, lemon-yellow to brown growth.

Fermentation tubes.—No acid, no gas, no growth in closed arm in any sugar bouillon.

Bouillon.—A sediment and turbidity.

Milk.—Rendered alkaline. Sometimes there is a curdling and sometimes not, but the milk always digests.

Potato.—Luxuriant, yellow to lemon-yellow, with a discolored potato.

Grows best at 20°; slightly at 37°. Aerobic.

This was very abundant in a Camembert cheese sent us from France. It differs only slightly from the last described type, being intensely alkaline on litmus gelatine, and having a very luxuriant potato growth. The two are closely allied and are perhaps the same.

M. lactis minutissimus. A minute, liquefying Coccus. Has been found but once, from milk in Middletown.

Morphology.—Size, .2μ–.3μ. Gram stain negative.

Gelatine colony.—Round, thin, smooth, in a clear, liquefying pit. Liquefaction slow.

Gelatine stab.—An infundibuliform liquefaction, with a granular layer on the surface, or sometimes only a deep, dry pit.

Agar streak.—Scanty, thin, smooth, yellow to lemon yellow.

Fermentation tubes.—Lactose is acid; the other sugars are not acid, and no gas nor closed arm growth is produced.

Bouillon.—A sediment and turbidity, but no pellicle.

Milk.—No change in the reaction, but the milk is promptly curdled and then digested, with a prominent odor.

Potato.—A white, dry, wrinkled, luxuriant growth.

Grows best at 20°; slightly at 37°. Aerobic.

M. lactis aureus A n. s. *A yellowish, liquefying Micrococcus.* This organism is very much like *M. lactis varians*, and may be the same. (See p. 121.) The only essential difference is the lack of acid production, and on this ground we separate them, although we regard them as allies, or identical. This type is comparatively rare, while the *varians* type is very abundant. Certain variations from the described type are found in other cultures, and are indicated in brackets.

Morphology.—Size, .8μ–1μ. Gram stain positive.

Gelatine colony.—A V-shaped colony is formed in a pit surrounded by a halo. It is irregular, globate or entire; later it liquefies.

Gelatine stab.—A stratiform liquefaction, with a yellow sediment. Liquefaction begins on the second day and is complete in fourteen days.

Agar streak.—A luxuriant, brownish-yellow growth. [White with yellowish tinge.]

Fermentation tubes.—No acidity nor gas is produced.

Bouillon.—A pellicle and turbidity, with no sediment. [Sediment and no pellicle.]

Milk.—Alkaline and curdled; the milk subsequently digested into a clear liquid, with a half inch of sediment. [No digestion.]

Potato.—A luxuriant, brownish-yellow growth.

Grows at both 20° and 37°. Aerobic.

Two types of yellow cocci, unnamed, described by Freudenreich, belong here.

The white liquefying cocci are very numerous and we have studied many separate cultures of them. Whether they should all be grouped together is uncertain. We have endeavored to arrange them in sub-groups, as shown below, but are convinced that these represent only physiological varieties of the same type. We are also of the opinion that this group is simply a liquefying form of the white coccus, *Gal. versicolor*. (See p. 110.)

M. lactis albus n. s.

Morphology.—Size, .7μ–1μ. Gram stain is positive; no chains.

Gelatine colony.—Round, moderately luxuriant, thick, smooth colonies, which may liquefy or in some cultures do not liquefy. In *litmus gelatine* the colony is dense and alkaline.

Gelatine stab.—A very slow liquefier, that commonly forms a dry pit with a white growth on its sides.

Agar streak.—Moderately luxuriant, opaque, whitish.

Fermentation tubes.—No acidity, gas, or closed arm growth in any sugar bouillon.

Bouillon.—A very slight growth, showing a slight turbidity and a sediment but no pellicle.

Milk.—Rendered alkaline and digested without curdling. Later the milk becomes pinkish and slimy.

Potato.—Luxuriant, thick white.

Grows at 20° and 37°. Aerobic.

Variety A.—Shows a viscosity on agar and sliminess in milk.

Variety B.—Shows no viscosity; a wrinkled growth on agar; a pellicle on bouillon and a discolored potato. Milk is curdled at 37°.

Variety C.—Has a moruloid colony that slowly liquefies, produces a pellicle on bouillon, and no milk digestion.

Variety D.—Liquefies more rapidly and curdles milk.

Variety E.—A very large coccus, 2μ in diameter.

Variety F.—A very slow liquefier, curdling and digesting milk; the milk after some weeks turning to a dark mahogany color. Potato growth is dry and velvety.

To this same group belong doubtless the small coccus *b.* of Freudenreich.

II. Acid in dextrose or other sugars.

M. lactis fluorescens n. s. Only one *fluorescens coccus* has been found, in stable dust.

Morphology.—Size, .5μ–.6μ. Gram stain negative.

Gelatine colony.—A round, moderately thick, smooth, entire colony, with a greenish liquefaction. *Litmus gelatine* shows liquefying pit that is not acid.

Gelatine stab.—A stratiform liquefaction.

Agar streak.—A luxuriant, narrow, rather thick, smooth, white growth, with a green fluorescence.

Fermentation tubes.—Dextrose is rendered acid, the other sugars alkaline; no gas is produced. Growth appears in closed arm.

Bouillon.—A sediment, turbidity, and pellicle.

Milk.—Rendered slightly acid, curdled, and later completely digested into a greenish-yellow liquid.

Potato.—Scanty, thin, smooth, white.

Grows at both 20° and 37°. Facultative anaerobic.

M. lactis varians n. s. *Yellow, liquefying, acid-producing Cocci.* This is perhaps the most common and widely diffused type of coccus found in milk. We have found it in milk from many localities, and it is very abundant. It is frequently present in milk directly from the udder. It shows a wide range of variations affecting nearly every character. We have studied some scores of independent cultures from different sources, and find that the different types grade into each other by such slight differences that we have no hesitation in putting them all together as one type. This organism liquefies gelatine, but in some cases so slowly as to form only a dry pit. From this it is only a step to a non-liquefying form. We, therefore, are inclined to believe that this type is identical with, or at least closely allied to, *M. lactis aureus* (p. 112). The characters as we have studied them agree essentially with those of *Staph. pyogenes aureus*. Cultures of the latter organism, sent us by Retger, have been compared side by side with our cultures and no essential differences are seen. We are inclined to think, therefore, that our type is the common *Staph. pyogenes aureus*. In the description that follows the limits of variations will be given under each head and no attempt will be made to distinguish distinct varieties.

Morphology.—Size, .4μ–1.4μ. Gram stain positive.

Gelatine colony.—Deep colonies are opaque; surface colonies form white or yellowish beads or a slow liquefying colony with a clear liquid and a granular, mottled, irregular growth, distributed in the liquid. It is usually slightly acid in litmus gelatine, sometimes decidedly so, forming a bright red liquid colony.

Gelatine stab.—Liquefaction is usually slow but sometimes rapid. It commonly begins in from two to four days, but is never complete. In some cultures liquefaction is so slow that only a dry pit is formed, with a broken, yellow growth on its side. It is usually napiform.

Agar streak.—A luxuriant growth, frequently tending to be rough, though never wrinkled. It does not spread profusely. Its color is typically pale orange-yellow, but varies from this to nearly orange and to practically white. In the latter case this is quite indistinguishable from *M. lactis albidus* (p. 123). The agar growth may be dry or moist.

Fermentation tubes.—All three sugars are rendered acid and growth appears in the closed arm. No gas is ever formed. Some cultures do not grow in the closed arm and some have failed to render lactose and saccharose acid.

Bouillon.—A flocculent sediment is produced and a slight turbidity. Two cultures showed a granular pellicle.

Milk.—Is always rendered acid and commonly curdled and digested with a yellow sediment. In the non-liquefying cultures the curdling may not appear nor any noticeable digestion.

Potato.—Is usually luxuriant, though sometimes scanty, of a pale orange-yellow color, showing the same variations as mentioned in agar streak. It is frequently dry.

Grows better at 37° than at 20°. Facultative anerobic.

These variations clearly run into *M. lactis aureus* on one hand and *M. lactis albidus* on the other, so that a sharp separation is impossible. This corresponds to *Mic. E.* of Barthel and is probably everywhere distributed.

This organism is not only common in this country but it appears to be common in Europe as well, several described forms doubtless belonging to the type, for example, *Stall-luftbacterium I.* of Koning and others. Koning's *Stall-luftbacterium II.*, which he regards as different, shows such slight variations from this that it also comes within the limits that may properly be regarded as covered by our *M. lactis varians.*

M. lactis varians A.—Under this head we recognize two cultures derived from milk fresh from the udder, agreeing with the type in all points except the following:

Acid is produced in dextrose only.

Milk is not rendered acid, although it may be curdled and digested.

We do not think this is sufficiently different to constitute a new type, but tabulate it here separately.

M. lactis giganteus n. s. *An extremely large, liquefying Coccus.*

Morphology.—Size, 1.4μ–3.5μ. A micrococcus which accepts the Gram stain. Its peculiarity is the very large size which the coccus sometimes reaches—3.5μ in diameter.

Gelatine colony.—A clear, liquefying pit, which is slightly cloudy and white. *Litmus gelatine* is not acid.

Gelatine stab.—Begins to liquefy in one day, infundibuliform.

Agar streak.—A moderately luxuriant, smooth growth, of an orange color.

Fermentation tubes.—All sugar bouillons are made acid, but there is no gas nor closed arm growth.

Bouillon.—A sediment, but no turbidity nor pellicle.

Milk.—Rendered acid and digested into a yellow liquid at both 20° and 37°.

Potato.—A scanty, beady, brownish growth.

Grows at both 20° and 37°. Aerobic.

This agrees with the last in its physiological properties, but the extraordinary size of the cells is so peculiar that we have given it independent rank.

M. lactis rugosus n. s. *A salmon-yellow Coccus.* Perhaps *M. acidi lactici* of Krüger.

Morphology.—Size, 1μ–1.2μ. Gram stain irregular; micrococcus.

Gelatine colony.—A liquefying pit, with a clear centre and a ring of granular matter; white.

Gelatine stab.—A slow liquefier, crateriform or stratiform.

Agar streak.—A salmon-yellow growth, luxuriant and viscous, wrinkled, with a dull surface and a salmon-yellow color.

Bouillon.—A sediment, turbidity, and a ring-like pellicle.

Milk.—Rendered acid and curdled, with an orange color and a sour odor; no digestion.

Grows well at 20° and 37°. Aerobic.

We have found this only once. Krüger apparently found the same in milk and butter. His organism differed from ours in digesting milk. The salmon color gives it independent rank.

The white, liquefying, acid-producing cocci form another series of extremely common Bacteria, with a long list of variations. As already mentioned, they pass, by imperceptible grades, into the yellow acid cocci, and should, perhaps, be united with them. These white cocci appear identical in cultural characters with *Staph. pyogenes albus*, a culture of which, when compared side by side, showed no essential differences. *Staph. mastitis albus* of Guillebau seems also to be essentially the same, as well as four different varieties of white cocci described by Freudenreich. (*Milchztg.* 1905, pp. 628 and 643.) These white cocci are extremely common in milk, in the udder, in the dust of the stable, and have been found in many samples of milk here and elsewhere. Among the many variations some are quite striking, and we have, therefore, endeavored to separate the various strains studied in groups, as follows:

M. lactis albidus n. s.

Morphology.—Micrococci. Size, .6μ–1.2μ. Stains by Gram method.

Gelatine colony.—An opaque colony, usually white, and soon liquefying. It is not characteristic. On *litmus gelatine* it is sometimes acid and sometimes not acid.

Gelatine stab.—Liquefies in from one to three days, infundibuliform. Sometimes a dry pit is formed, which may liquefy after several days.

Agar streak.—A moderately luxuriant, smooth, white growth; not very thick.

Fermentation tubes.—All sugars are rendered acid but no gas is formed, and there is usually no closed arm growth. (One culture did not produce acid or grow in bouillon.)

Bouillon.—A sediment and turbidity, but no pellicle.

Milk.—Usually rendered acid, and may or may not curdle. Curdling is more common, however, than not curdling. The milk is digested, except in those cultures that do not liquefy gelatine. One culture, however, liquefies gelatine, but does not curdle milk.

Potato.—A moderate growth, white to yellow; not characteristic.

Grows at 20° and 37°. Facultative anaerobic.

To this type belongs the white cocci of Guillebau and Freudenreich.

Variety A.—This differs from type Variety A chiefly in producing a snow-white growth on agar. Two cultures were studied, one of which produced a snow-white colony in gelatine, and the other lacked snow-white color. One of the two was snow-white on potato, while the other produced a thin, scanty growth. In all other respects they resemble the type.

Variety B.—This is separated from the others by its more anaerobic character, as shown by growth in the closed arms of the fermentation tubes. The colonies on litmus gelatine are acid; the agar growth is scanty, as is also the growth on potato. This was found on Cheddar cheese and Camembert cheese.

Variety C.—Distinguished from the others chiefly by not making milk acid and by not curdling. One culture of this variety renders the milk alkaline,

curdles and digests it. The acidity in sugar bouillon is less pronounced than in the other varieties, and in lactose there is usually no acidity. The litmus gelatine colonies are usually acid, though not always. In other respects they agree with the type.

M. Freudinreichii of Guillebeau appears to belong here, differing from those mentioned above in rendering milk *slimy*.

THE GENUS SARCINA.

We have not found the genus sarcina very commonly represented in milk products. The cultures which we have found may all be reduced to four types; for, while the different specimens show some variations, they are not very great, and not so great but what they may be properly included under one of the four types.

Sar. lactis albus n. s. *A white or yellow non-liquefying Sarcina.*

Morphology.—Size; .7μ. The Gram stain is positive and there is no motility.

Gelatine colony.—Round, convex, smooth, homogeneous, entire, yellowish or white.

Gelatine stab.—A needle growth and a convex surface growth.

Agar streak.—Beaded, raised, smooth, translucent, cream-white, moist, not luxuriant.

Fermentation tubes.—Acidity and closed arm growth in all sugar bouillons, but no gas. Sometimes lactose shows no closed arm growth.

Bouillon.—A sediment and a slight turbidity, but no pellicle.

Milk.—Becomes sufficiently acid to curdle on boiling. No other change.

Potato.—A very slight cream-white growth.

Grows at 20° but scarcely at all at 37°. Facultative anaerobic.

Sar. lactis lutea n. s. *A yellow, liquefying Sarcina.* Resembles *Sar. lutea* of Flügge.

Morphology.—Size, .7μ–1μ. Gram stain positive. Not motile.

Gelatine colony.—A slow liquefying pit, with a nucleus surrounded by granular area; yellowish. Litmus gelatine not acid.

Gelatine stab.—Begins to liquefy in about three weeks, crateriform, and never complete.

Agar streak.—Filiform, raised, smooth, opaque, lemon-yellow, luxuriant.

Fermentation tubes.—No acidity, no gas, no closed arm growth in any sugar bouillon.

Bouillon.—A sediment, but no turbidity nor pellicle.

Milk.—Becomes alkaline and slowly digests, with a yellow color, but does not curdle.

Potato.—Beaded, raised, opaque, lemon-yellow, luxuriant.

Grows at both 20° and 37°. Aerobic.

Among the variations found in our several cultures the following may be mentioned: Size, from .7μ–2μ; color, lemon-yellow to whitish; the reaction on milk is frequently not changed; the growth on potato ranges from luxuriant to no growth.

Sar. lactis aurantiaca n. s. *An orange, liquefying Sarcina.* This may be the same as the last, but its color is quite different and it shows some other differences. Probably *Sar. aurantiaca* of Flügge.

Morphology.—Size, 1μ. Gram stain positive, non-motile.

Gelatine colony.—A liquefying pit, forms with an orange pigment. Litmus gelatine is not acid.

Gelatine stab.—A slow liquefaction, stratiform.

Agar streak.—Filiform, raised, smooth, moist, orange, luxuriant, slightly viscous.

Fermentation tubes.—No acidity, no gas, no closed arm growth in any sugar bouillon.

Bouillon.—A sediment, a membranous pellicle and a slight flocculent sediment.

Milk. No change in reaction, or a slight alkalinity; the milk is curdled and digested. Digestion is nearly complete, with an orange sediment.

Potato.—Spreading, capitate, contoured, orange color, luxuriant; potato discolored.

Grows at both 20° and 37°. Aerobic.

Sar. lactis acidi n. s. *An acid, yellow Sarcina.*

Morphology.—Size, .8μ–1μ. Gram stain positive; not motile.

Gelatine colony.—Round, raised, smooth, homogeneous, opaque, brownish, slowly liquefying.

Gelatine stab.—Liquefaction very slow and sometimes only a dry pit is formed, with a yellow bacterial growth.

Agar streak.—Filiform, raised, smooth, cream-white, moist, not very luxuriant. Color is sometimes yellow.

Fermentation tubes.—Acidity produced in all three sugar bouillons (it may be lacking in saccharose), but there is no gas nor closed arm growth.

Bouillon.—A sediment and a slight turbidity, but no pellicle. (Turbidity sometimes absent.)

Milk.—Becomes acid, but does not curdle or digest.

Potato.—Does not grow well, but there is a slight cream-colored growth.

Grows at both 20° and 37°, though not very abundantly at 37°. Aerobic.

THE GENUS BACTERIUM, NON-LIQUEFYING.

I. No acid in dextrose or other sugars.

Bact. lactis salmonis n. s. *A salmon-colored Bacterium.*

Morphology.—Size, .6μ x 1μ–1.8μ, forming chains. Gram stain is positive and there are no spores nor capsules.

Gelatine colony.—Round, umbonate, contoured, lobed, white. Litmus gelatine colonies are strongly alkaline and transparent.

Gelatine stab.—Needle growth and a raised surface growth.

Agar streak.—Filiform, thin, smooth, white to yellow, and later a salmon or pink color.

Fermentation tubes.—No acidity, gas, nor closed arm growth in any sugar bouillon.

Bouillon.—A flocculent sediment, a membranous pellicle and a slight turbidity.

Milk.—Becomes alkaline, but shows no other change.

Potato.—Luxuriant, thick, contoured, flesh color or pink.

Grows well at 20°; slightly at 37°. Aerobic.

This was found by Harding in a specimen of green butter.

Bact. lactis aureum I. An orange, non-acid Bacterium. Perhaps *B. lactericus* of Adametz.

Morphology.—Rods which do not form chains. Size, .7μ–.9μ x 1μ–3μ. No spores are produced, a capsule is evident and Gram stain is positive.

Gelatine colony.—Round, flat, contoured, lobed, orange to yellow color. Litmus gelatine colonies are of a red-brown color.

Gelatine stab.—A needle growth and a thin, reddish surface growth.

Agar streak.—Luxuriant, deep orange-brown color, tough and tenacious, sometimes dull, and aggregated in colonies.

Fermentation tubes.—No acidity, gas, nor closed arm growth in any sugar bouillon.

Bouillon.—A turbidity, sediment, and a pellicle.

Milk.—No action except a slight orange color at the surface.

Potato.—Growth scanty or absent; when present, of an orange color.

Grows better at 20° degrees than at 37°. Aerobic.

Found in Middletown and in New York city.

Bact. lactis citreum II. n. s. *A yellow, non-acid Bacterium.*

Morphology.—A rod occasionally forming chains. Size, .5μ–.7μ x .7μ–1.4μ. No spores nor capsules, and Gram stain negative.

Gelatine colony.—A round, opaque bead, 1.5 mm. in diameter; usually white and later turning yellow.

Gelatine stab.—A scanty needle growth and an irregular, dry, white surface.

Agar streak.—Luxuriant, at first white, but soon lemon-yellow.

Fermentation tubes.—No acidity, gas, nor closed arm growth in any sugar bouillon.

Bouillon.—Turbidity, sediment, and a flaky scum.

Milk.—No action.

Potato.—Luxuriant, yellow, thick, sometimes wrinkled.

Grows both at 20° and 37°. Aerobic.

Variety A.—This has a small lemon-yellow colony on gelatine which is lemon-yellow even when viewed under the microscope. It has also a lemon-yellow surface growth on the gelatine stab and a lemon-yellow growth on potato.

Variety B.—Produces a yellow pigment, but not lemon-yellow, both in gelatine colony and on potato. It is slightly viscous on agar, and has no pellicle on bouillon. Potato is slightly discolored, and one culture failed to grow on potato. All from milk.

The white non-acid bacteria are very numerous and show many slight variations. We have tried to separate them into groups, but they are all more or less connected by intermediate forms and our grouping is not very satisfactory.

Bact. lactis myceloidium. A mycoloid, non spore-bearing Bacterium. We have studied two cultures of this type, one from this locality and one sent us by Weigmann, from Kiel, as *Bact. mycoides.* The Kiel culture is not *mycoides*, for it fails to produce spores and does not liquefy gelatine. This raises the question whether it may not be a cultural variety of *B. mycoides*, having lost these two properties. As tested in our laboratory, it had the following characters:

Morphology.—Long filaments, the individual elements of which are .7μ x 2μ–3.5μ. The Gram stain is irregular and there are no spores.

Gelatine colony.—A myceloid colony, 2 cm. in diameter, spreading rapidly; largely under the surface.

Gelatine stab.—A needle growth and a surface growth; a layer of threads is seen extending horizontally, a short distance below the surface, to the sides of the tube.

Agar streak.—A luxuriant, moderately thick, slightly yellowish growth.

Fermentation tubes.—No acidity, gas, nor closed arm growth in any sugar bouillon.

Bouillon.—A sediment and turbidity, but no pellicle.

Milk.—Becomes slightly acid, but does not curdle, even when heated, and shows no other change.

Potato.—A scanty growth, thin, white.

Grows better at 20° than at 37°. Aerobic.

We have found a local variety of the above, agreeing with it in most respects. It is shorter, .9 μ, does not show the peculiar horizontal growth in gelatine stab, and produces no acidity in milk.

Bact. lactis arborescens I. n. s. *An arborescent, non-acid Bacterium.*

Morphology.—Size, .9μ x 1.2μ–1.4μ. It has no spores nor capsules, forms no filaments, and Gram stain is negative.

Gelatine colony.—Round, raised, smooth, entire, white colony. On litmus gelatine brownish and not acid.

Gelatine stab.—An arborescent needle growth and a surface growth.

Agar streak.—Scanty, thin, white to cream color, slightly viscous.

Fermentation tubes.—No acidity, gas, nor closed arm growth.

Bouillon.—A sediment, ring-formed pellicle, and a slight turbidity.

Milk.—Is rendered alkaline and slimy. After some days it becomes slightly transparent, indicating a slight digestion.

Potato.—Scanty, raised, grayish-brown color; potato discolored.

Grows at both 20° and 37°. Aerobic.

This organism was sent us from Michigan by Marshall, but we have not ourselves found it. Its slight digestion of milk and its slight pit in gelatine stab suggest an intermediate step toward a liquefying form. If regarded as a slow liquefier it is not unlike *Bact. arborescens* Frankland, found in water.

Bact. lactis viscosum Adametz. Under this name are included several slimy milk bacteria described by different observers. The first was described by Adametz, others by Ward, Harrison, Freudenreich, and Marshall. We have had an opportunity of studying all of these except that of Adametz, from original cultures from the authors. We have also received a similar culture from New York city milk. These have all been carefully studied by Harrison who regards them as a single type and calls them group 1. We are in agreement with him in recognizing this as a logical group. Its general characters are as follows:

Morphology.—Size, .5μ–1.2μ x .5μ–2.5. Frequently narrower at the ends. Forms filaments, 15μ in length. The slime seems to be produced from a capsule, but this is not always seen. Gram stain negative.

Gelatine colony.—Flat colonies, with irregular edges, or lobate. 3 mm.–6 mm. in diameter. Later viscous.

Gelatine stab.—A good needle growth, which may be separated into granules. Sometimes arborescent, but not always so. A thin, shiny, gray surface growth, lobate.

Agar streak.—Usually luxuriant, viscous, white, not very thick.

Fermentation tubes.—No acidity, gas, nor closed arm growth in any sugar bouillon.

Bouillon.—Turbidity, pellicle, and sediment. (The organisms of Ward, Harrison, and Freudenrich show no pellicle.)

Milk.—Becomes alkaline, does not curdle, but is very slimy.

Potato.—A thick, uneven, dirty gray, becoming brown or yellow; slimy.

Grows at both 20° and 37°. Aerobic.

We retain the name of Adametz, changing the word Bacillus into Bacterium. I see no good reason for separating the above mentioned organisms even as varieties. Many cases of slimy milk infections in dairies are produced by this type of bacterium, which is probably the most common cause of such troubles.

Bact. lactis acidi. Var. E. This organism is very similar to *Bact. acidi lactici* (see page 134). In all of its characters, except one, it agrees with that type. It shows the same unwillingness to grow in common culture media in the laboratory, and little or no surface growth, but it produces no acidity in sugar bouillons and no acidity in milk. Inasmuch as *Bact. acidi lactici* shows great variations in the power of producing acids, we regard this as an extreme variety of that type. No further description here is necessary.

Bact. lactis Connii Chester. *A white non-acid Bacterium.* Large numbers of common white bacteria have been found without striking characters. They are common in all milk. We have found them more or less constantly here and in New York milk. They are also common in cheese, and constitute the chief bacterium in the red slime of Camembert cheese. In our former report we recognized two or three different types among them, but at present we believe they should all be grouped together under one head. We have retained the name given by Chester. It is parallel with *Galactococcus versicolor* among the cocci; it may be identical with the latter.

Morphology.—A bacterium (.5μ–.7μ x 1.4μ), forming short chains. It has no spores nor capsules and the Gram stain is negative.

Gelatine colony.—Round, raised, smooth, entire, white or cream color. *Litmus gelatine* shows a non-acid, white, not characteristic surface colony.

Gelatine stab.—A good needle growth and a white surface.

Agar streak.—Luxuriant, filiform, raised, smooth, white, opaque.

Fermentation tubes.—No acidity, gas, nor closed arm growth in any sugar bouillon.

Bouillon.—A sediment, ring-formed pellicle, and slight turbidity.

Milk.—Rendered slightly alkaline, is not curdled, and shows no digestion. In one case milk became pasty in about three weeks.

Potato.—Luxuriant, convex, smooth, white, potato discolored.

Grows both at 20° and 37°. Aerobic.

Among the numerous cultures which we have studied we can recognize two sub-varieties.

Variety A.—A less vigorous organism than the one described. Size, 1.4μ x 1.2μ, forming rather long filaments. Bouillon sometimes shows no pellicle and milk is not rendered alkaline. Potato growth is rather scanty. The potato shows no discoloration, but the growth itself is slightly yellowish.

Variety B.—Stains by the Gram method; agar streak is dry and wrinkled; dextrose slightly acid; no discoloration of potato.

This seems to be identical with *B. lactarius* of Adametz and a Bacterium described by Burri and Dugelli, mentioned as having a "dog odor" appears also to be the same.

II. Acid in Dextrose or other Sugars.

Bact. rudensis Connelli. *A red, acid Bacterium.* This organism was isolated by Harding from cheese vats, and regarded by him as the above species. Four cultures were sent to us by him after he had kept them in stock for a year. Of these four cultures two came originally from Canada; two of them had entirely lost their power of producing red pigments, and two still gave a slight red color to milk. All were said to produce red pigment originally. The cultures which I received had also totally lost their flagella and motility, and in this condition were not distinguishable from *B. lactis acidi*, except by showing a better growth on potato. These cultures, when studied by us, had the following characters.

Morphology.—A short rod, 1μ x 1.8μ; forming no chains, showing no spores, and staining by the Gram method (originally motile).

Gelatine colony.—A small colony, mostly under the surface, quite dense. On *litmus gelatine* it is intensely acid.

Gelatine stab.—A needle growth, but no surface growth (originally a thin surface).

Agar streak.—No visible growth, or sometimes an extremely thin transparent growth.

Fermentation tubes.—Acidity and closed arm growth in all sugar bouillons, but no gas.

Bouillon.—A sediment and slight turbidity, but no pellicle.

Milk.—Becomes acid and curdles promptly at both 20° and 37°. A rusty precipitate appears in some cultures.

Potato.—Scanty, reddish-brown color (originally showing yellowish colonies that become red).

Grows at both 20° and 37°. Facultative anaerobic.

If this colorless variety should be met incidentally in milk, it would never be thought to be *Bact. rudensis*, and would doubtless be placed with *Bact. lactis acidi* group, and perhaps be regarded as identical with that organism. This raises the question naturally whether other members of that group may not be albino types of pigment-producing bacteria. So far as we know we have never found this species, although we have no proof that some of our white types are not such albino varieties.

Bact. lactis catenensis n. s. *Yellow spore-bearing Bacterium.*

Morphology.—Size, .7μ x 1.2μ; producing chains. Gram stain is negative, and small spores are produced. In old cultures the rods may be much smaller, .5μ.

Gelatine colony.—Round, raised, smooth, homogeneous, transparent, and of a yellow to white color. On *litmus gelatine* the color is yellow to gray, not acid.

Gelatine stab.—A good needle growth, and a flat orange-yellow surface.

Agar streak.—Orange to yellow, thin, and sometimes wrinkled.

Fermentation tubes.—Dextrose and lactose acid, saccharose not acid. No gas or closed arm growth.

Bouillon.—A sediment, turbidity, and a pellicle.

Milk.—No effect, as a rule, but one culture curdled milk, acid at 37°.

Potato.—Luxuriant, wrinkled, orange-yellow.

Grows at 20° and 37°, but better at 20°. Aerobic.

Three cultures of this general type have been studied from Middletown, Cromwell and New York. The first was orange, the second lemon-yellow, and the third brown-orange on agar, and white on potato and gelatine. The last did not show a wrinkled growth on agar, although it did on potato.

Bact. lactis aureum II. n. s. *An orange, acid-forming Bacterium.*

Morphology.—Size, .8μ–1.2μ x 1.2μ–1.8μ. No chains, no spores. Gram stain negative.

Gelatine colony.—Round, convex, smooth, entire, orange-yellow. On *litmus gelatine* it is thin and not acid.

Gelatine stab.—A needle growth and a thin surface growth.

Agar streak.—Moderately luxuriant, filiform, thin, smooth, orange color, moist.

Fermentation tubes.—Dextrose acid, lactose and saccharose slightly acid; no gas nor closed arm growth.

Bouillon.—No visible growth.

Milk.—Very slightly alkaline, no curdling and no digestion.

Potato.—Spreading, thin, smooth, yellow.

Grows better at 20° than at 37°. Aerobic.

This organism was sent me by Gorini from Italy. Another, which seemed to be identical, was found in milk here, the only points of difference being a luxuriant potato growth and a slight sediment in bouillon. A very similar culture was sent by Harding, differing only in having a somewhat dry, wrinkled growth on agar. We regard the three as identical.

Another culture is very closely related to this, but differing in enough particulars to lead us to regard it as a separate variety.

Variety A.—This organism was found here on Camembert cheese and another culture was sent us by Gorini. It differs from the above described type only in the following points: Size, .9μ–1.5μ x .5μ. Gram stain positive, grows well in bouillon, with a sediment. Milk distinctly alkaline. Color of a lemon instead of an orange yellow.

Variety B.—This organism, sent by Harding, differs from the type in producing a rather more orange color, a turbidity and sediment in bouillon, and in making milk distinctly acid, but not curdling it.

Bact. lactis synxanthum.—A culture of this organism, several years old, was sent me by Harrison. It had completely lost its power of producing yellow pigment. Below are given its characters as made out by us, and in brackets the characters as originally described where they differ from those observed.

Morphology.—Size, .8μ–.9μ x 1.2μ–2μ. No spores, no chains. A capsule is evident. Gram stain is negative. [Gram stain positive, motile.]

Gelatine colony.—Round, capitate, smooth, homogeneous, entire, opalescent, gray, moist. [Luxuriant, gray, yellow.] On *litmus gelatine* transparent, white colonies.

Gelatine stab.—A needle growth and a raised surface growth.

Agar streak.—Luxuriant, filiform, raised, smooth, opaque, porcelain white. Slightly viscous. [A yellow pigment, soluble in water.]

Fermentation tubes.—All three bouillons are acid, but there is no gas nor closed arm growth.

Bouillon.—A sediment, slight turbidity, and a ring-formed pellicle.

Milk.—Becomes acid but does not curdle nor digest. [Alkaline, and digests to a bright yellow color.]

Potato.—Filiform, raised, contoured, sebaceous, gray, luxuriant; potato discolored.

Grows at both 20° and 37°. Aerobic.

These organisms show how decidedly characters which are relied upon to distinguish types may disappear after long cultivation, and naturally throws doubt upon all classifications based upon physiological properties. If an organism originally isolated because of its power of producing red pigment lose this power absolutely, and if one which produces a brilliant yellow color loses this property, we naturally ask whether any physiological properties are constant.

Bact. seifige Milch Weig. This organism from soapy milk we have had an opportunity of studying from a culture sent by Weigmann. The culture had been under observation in his laboratory for some years before it was sent and did not agree in all its characters with his original description. The description below is of the culture which we have studied and where it differs from the original description, the latter is indicated in brackets.

Morphology.—Size, 1μ x .5μ. No spores, no capsules. Gram stain negative.

Gelatine colony.—Round, capitate, smooth, homogeneous, entire, translucent, gray-white. On *litmus gelatine* it grows chiefly below the surface and is strongly acid. After some days the acid reaction changes to alkaline.

Gelatine stab.—A needle growth and a raised surface growth, which later becomes a dry pit [slowly liquefying].

Agar streak.—Filiform, thin, smooth, opalescent, gray, moist, not luxuriant. [Of a yellow color.]

Fermentation tubes.—All three sugar bouillons become acid, but there is no gas and no closed arm growth.

Bouillon.—A sediment and turbidity, but no pellicle.

Milk.—Becomes amphoteric and a slight yellow scum appears around the rim. [Originally this produced a soapy taste in milk, but did not do so when studied by us.]

Potato.— Filiform, thin, smooth, brownish, moist, luxuriant [yellow].

Grows at both 20° and 37° [best at 10° according to Weigmann]. Aerobic.

Bact. lactis Isignii n. s. This bacterium has the unusual character o completely digesting milk into a transparent liquid without previous curdling, but not liquefying gelatine. It is the only species we have found showing this character. It was found upon an Isigny cheese and constituted about 44% of the bacteria on the cheese.

Morphology.—A small rod, not forming chains. Size, .5μ–.3μ. It forms no spores nor capsules, and the Gram stain is negative.

Gelatine colony.—Round, raised, smooth, homogeneous, entire, opaque, yellowish, moist.

Gelatine stab.—A filiform needle growth, and a flat surface.

Agar streak.—Luxuriant, filiform, raised, smooth, translucent, yellowish, moist.

Fermentation tubes.—After three days an acidity in all three bouillons, but no gas and no closed arm growth.

Bouillon.—A sediment, slight turbidity, but no pellicle.

Milk.—Becomes slightly acid and digests. After two months the digestion is complete.

Potato.—Spreading, flat, smooth, cream-white, luxuriant.

Grows at both 20° and 37°. Aerobic.

Bact. lactis non-acidi n. s. This organism belongs to the lactis series (see below), but the departure from the central type becomes so great as to properly demand a separate name. The surface growth is very abundant and the acid production very feeble. The dextrose alone is rendered acid. Milk is never acidified nor curdled. The complete description is as follows:

Morphology.—Size, 1.8μ x 5μ–1.2μ. Sometimes long chains are formed. There are no spores and the Gram stain is irregular, commonly negative, but in two cultures was positive.

Gelatine colony.—Small, round, moderately thick, entire or irregular margin, white. *Litmus gelatine* colony is not acid and sometimes distinctly alkaline. Sometimes green. The colonies of different cultures show considerable variation which may indicate different varieties. Our data, however, at present do not warrant us in separating them.

Gelatine stab.—A needle growth and a spreading, moderately abundant surface.

Agar streak.—Moderate to luxuriant, linear, smooth, white, moist.

Fermentation tubes.—Dextrose acid, and sometimes lactose and saccharose.

Bouillon.—A sediment and turbidity, and frequently, though not always, a pellicle.

Milk.—Alkaline, or no change in reaction, no digestion nor other change.

Potato.—Scanty to luxuriant, white, spreading. One culture was wrinkled.

Grows at both 20° and 37°, though better at 20°. Aerobic.

The variations given above are large and we feel that this group should be broken up. But the different variations mentioned cross each other so much that we have as yet been unable to divide them into any definite varieties. As more cultures accumulate and give us more information we believe it will be possible to recognize some sharply distinct types, but at present we leave them together. The variations which we have found fail to group themselves, and if we should try to make varieties we should be obliged to recognize nearly as many as we have isolated individual cultures.

This type of lactic bacteria is very common. It appears constantly in milk in this vicinity as well as in New York state, and in cheese. It does not seem to be, however, so vigorous as the typical lactic organism, and is apparently not the cause of ordinary sour milk.

Bact. lactis ubiquitum. This organism we have not especially studied since its description in 1899. We reinsert here the description then given:

Morphology.—Size, 1.2μ–1.4μ x .8μ. Long chains are formed; spores are developed and also a capsule.

Gelatine colony.—Round, capitate, smooth, entire, white, the outer edge thinner and lighter.

Gelatine stab.—A needle growth and a rather thick irregular surface growth.

Agar streak.—A luxuriant, white surface growth, developing irregular frost-like or feather outgrowths. Moist, smooth.

Fermentation tubes.—Not determined, but probably acidity is produced, at least in dextrose and lactose, and there is no gas.

Bouillon.—A sediment and turbidity, but no pellicle.

Milk.—Rendered acid and is curdled after several days. No digestion.

Potato.—A luxuriant growth, transparent, spreading, white, glistening.

Grows well at both 20° and 37°. Aerobic.

WHITE, ACID-PRODUCING BACTERIA.

These are immensely numerous. They are the common cause of the souring of milk, and since this phenomenon is practically universal, it follows that these bacteria are equally widely distributed. This group contains the dairy bacteria par excellence. By this is not meant that these are most abundant around the barn or in fresh milk. As pointed out elsewhere, they are not common in the udder of cows, and are usually present only in small numbers in freshly drawn milk. But they are so much better adapted to life in milk that they soon become more abundant than all other bacteria put together. Thus in older samples of milk they are by far the most common.

We have studied hundreds of cultures belonging to this general type, obtained from all over this country, as well as from several localities in Europe. Among this large series of samples we have found endless variations. There is hardly a characteristic which does not show wide variations in the numerous cultures studied. They include such widely different types that it is hardly proper to put them into one group, but to arrange any satisfactory subordinate grouping is almost an impossibility. This might be done by selecting almost any of the characteristics of the type and arranging the different cultures according to its variations. The most satisfactory arrangement as appeared to us is to divide them according to their power of producing a surface growth on various media. This is not a sharp character, but it presents at least two extremes which may be clearly separated.

Heinemann (Cent. f. Bac. u., Par. II., XVI., p. 538, 1896) doubts whether the common lactic organisms should be called by the name Bacterium, believing that they are really all Streptococci. We are inclined to doubt the correctness of this view, and prefer to retain the long accepted nomenclature.

Bact. lactis acidi Leichmann. This is the common cause of sour milk. Among the many scores of organisms of this type which we have studied we have tried to recognize some groups worthy to be called varieties. Whether this is possible is uncertain, since all are connected by slight intermediate gradations. We recognize, however, the following:

Bact. lactis acidi, type.

Morphology.—A bacterium. Size, .7μ–1.2μ x .5μ–.8μ. Sometimes so short as to be described as a streptococcus, and some cultures are very clearly cocci. (See p. 114.) There is no motility, no spores, and no long chains. Gram stain is positive.

Gelatine colony.—Colonies are small points, rather opaque, not characteristic. They are almost wholly under the surface, and never typically grow on the surface. In *litmus gelatine* they are rather dense, strongly acid, and frequently, though not always, surrounded by minute, irregular spines on the edge. This type of colony can usually be detected with a little experience, and is the most characteristic feature of the type.

Gelatine stab.—A granular or linear needle growth, and no surface growth.

Agar streak.—There is no growth, or one that is scarcely visible. On milk agar it grows rather better, but at best it is very scanty.

Fermentation tubes.—All three sugar bouillons are rendered acid and there is commonly a closed arm growth, but never any gas.

Bouillon.—Frequently there is no sign of growth, but there is commonly a slight sediment.

Milk.—Milk is rendered strongly acid and promptly curdled in from six hours to two days. The curd is smooth and hard, without gas bubbles, and never shows any digestion.

Potato.—Usually no growth, but sometimes a thin, transparent film.

Grows at 20° and 37°, but better at 20°. Facultative anaerobic, growing better without oxygen, and hence curdling milk at the bottom first.

The most characteristic features of this organism are the peculiar *litmus gelatine colonies*, the *absence of surface growth*, and the *smooth*, *hard*, *acid curd in milk*.

Variety A.—This differs from the common type simply in its extremely minute colony, which is invisible to the naked eye, is merely transparent and does not show the characteristic spines. In our previous list this was called No. 202, but we now think that it is only a less robust form of the type. In all other respects the two agree perfectly. The difference of the colonies on gelatine, however, is usually very striking, that of the variety A being not more than 1-10 the size of the type. It is less frequently found, also, than that of the type.

Both the type and variety A show great variability in their acid-producing power. Sometimes they curdle milk in as short a time as six hours (at 37°), other cultures in twenty-four hours, others, again, in two or three days, and finally, some, identical in other respects, fail to curdle it at all, although they make it strongly acid. These variations in acid-producing power do not seem to us to be sufficient to warrant us in recognizing them even as varieties. They are certainly subject to modification in the same cultures. Cultivation in milk noticeably increases this power. Cultures, when first isolated, show a weak growth and a weak curdling power, but after a few days' growth in milk this power is very greatly increased. A gelatine plate made from fresh milk shows weak colonies, growing slowly, with a weak acid production. A plate made from the same milk after two days shows not only more numerous colonies but colonies much larger, more acid, and growing much faster. It appears thus that this organism adapts itself to milk, which seems to be its most favorite medium for growth.

This is the organism which, in previous papers (Annual Rep. Storrs Exp. Sta., 1901), we have shown to outgrow all other bacteria in milk at 20°, and commonly to comprise 99% or more of the bacteria in milk kept at 20°. We have found this organism all over the United States from the Pacific to the Atlantic, and it has been sent to us from Europe as one of the most common lactic bacteria there. It is present in practically every cheese which we have studied, including both hard and soft cheeses. It has been many times studied and been given very many different names. It appears to be the same organism which has received the following names by different authors: *Lactic bacterium* of Kozai, *Lactic bacterium* of Utz, *Strept. acidi lactici* of Marpmann, *Bact. lactis acidi* Leichmann, *B. lactis acidi* Günther and Thierfelder, *B. acidi paralactis a* of Freudenreich (also several others of his cultures are nearly identical), *Bacillus*

acidi lactici Esten. Of these various names that of Leichmann, *Bact. acidi lactici*, is preferable. The name given by Günther and Thierfelder has the priority, but since this organism is not a bacillus, that name cannot be retained.

Variety B.—This shows a dense, coarse, granular surface colony. It is very small, only .4μ–.7μ. It does not curdle milk, though it makes it acid and gives it an astringent taste. It was isolated by Harrison from astringent milk.

Variety C.—This differs from the type in the following points: The colony shows a surface growth, and there is also a surface growth in gelatine stab. There is abundant growth in bouillon, with a pellicle. This variety is evidently more aerobic than the type. One culture of this, from Camembert cheese, shows a capsule.

Variety D.—This variety never curdles milk though it makes it acid. It does not stain by the Gram method. It has a thick lobate or moruloid surface colony, or sometimes smooth. There is a spreading surface on gelatine stab and a scanty opaque growth on agar streak. Its acid production is feeble and there is no acidity in saccharose bouillon. In ordinary bouillon there is a sediment, turbidity, and usually a pellicle. Its growth on potato is scanty. We have found this several times in different cheeses, and it has also been isolated from all milk. *Milch bacterium I.*, of Koning seems to belong to this type. (Milchw. Zent. II. 1906, p. 316.)

At this place should be mentioned a series of milk organisms which are called "acid fast," *i. e.*, they are not decolorized, by NNO_3 after being stained with carbol fuchsin. In this respect they agree with the *tuberculosis bacillus*, and hence may sometimes be confused with them in an ordinary microscopic study of milk. For this reason they are of some considerable significance. At least nine of them have been described by different authors as follows: *B. phlei, Mist bacillus, Grass bacillus, No. 2, and Milk bacillus*, all described by Moeller; the *Butter Bacillus* of Grassberger; the *Butter Bacillus* of Binot; the *Butter Bacillus* of Rabinowitsch; the *Butter Bacillus* of Coggi; the *Bacillus Freiburgensis* of Koon; also *B. Freibengensis, No. 2*, and *Butter bacilli, Nos. 1, 2, 3, 4 and 5*, of Tobler. We have not had an opportunity of studying any of these, and the descriptions given of them are altogether too inadequate for classification according to our scheme. Some of them are acid producers and others are not. Some are white, others orange-yellow or reddish. They form a miscellaneous lot of bacteria whose relations can not be determined by the characters given. We find it quite impossible to place them in our scheme at the present time. It is quite possible that some of the bacteria which we have described are also "acid fast," for we have not used this method of staining in our routine tests.

THE GENUS BACTERIUM, LIQUEFYING.

I. No acid in dextrose or other sugars.

Bact. lactis chromatum n. s. *A lemon-yellow, spore-bearing Bacterium.*

Morphology.—Size, 3μ x 1.5μ. Chains are formed and spores produced, but there is no capsule.

Gelatine colony.—A liquefying pit, full of threads. There is a central nucleus with coarse granular masses around it.

Gelatine stab.—A deep, dry pit is first formed which, after several days, shows liquefaction.

Agar streak.—A luxuriant, moist, yellow to white growth.

Bouillon.—A sediment, turbidity, and pellicle. The liquid later becomes clear.

Milk.—Becomes alkaline and curdles. It subsequently digests into a clear liquid, with a tenacious scum.

Potato.—Luxuriant, dry, rough, wrinkled, with a brilliant yellow color.

Grows at both 20° and 37°. Aerobic.

Bact. lactis arborescens II. An arborescent spore-bearing Bacterium. This organism, originally found in 1896, has appeared once or twice subsequently, although the later organisms differed slightly from the original. One culture, sent by Weigmann, differed in points inclosed in brackets.

Morphology.—Rods with square ends. Size, 2μ–4μ x 1μ–1.8μ, forming long chains. Spores are produced but no capsules. Gram stain negative.

Gelatine colony.—A very peculiar felted mass of fibers extending through the gelatine, and a ground glass-like felted surface, on a liquefying disk. The appearance is variable, but the fibers are characteristic. [Myceloid.]

Gelatine stab.—An arborescent needle growth, liquefying slowly, infundibuliform, with a folded, ground glass-like scum.

Agar streak.—Widely spreading, filamentous and somewhat cotton-like on the surface and extending into the agar; luxuriant, wrinkled, dull. [Cretaceous.]

Fermentation tubes.—[Dextrose and saccharose acid, lactose not acid, no gas, closed arm growth in lactose and saccharose.]

Bouillon.—A flaky turbidity, a sediment, and a ground glass-like scum.

Milk.—Alkaline, curdled and digested. After digestion it may be amber-colored or colorless. One culture showed a ground glass-like scum.

Potato.—A luxuriant growth, with a white cotton-like surface, extending below into the potato.

Grows at both 20° and 37°. Aerobic.

In the specimens found later and regarded as the same as the above the arborescent needle growth was not always found, and the scum on the milk was lacking.

Bact. lactis filiformis, formerly described, is very similar to the last and may be the same. It has not been found since the original description. It differs only in the following points: No arborescent growth in gelatine. The ground glass-like appearance is lacking. The agar streak shows a dry, white, lobate growth. Bouillon shows a scum of tangled fibers, and on potato it forms a thick, slimy growth, yellowish, covering the whole surface of the potato.

Bact. lactis truncatum. A Bacterium with proteus or curled colonies. Described by us in a previous report and named by Chester. The following is a description of a culture studied more recently:

Morphology.—Size, 1.2μ–2.5μ x .8μ–1, forming long chains of square-ended rods. Spores are produced but no capsules.

Gelatine colony.—An opaque colony, ¾ inch in diameter in two days; curled, *i. e.*, made of twisted threads. In some cases the colony is proteus-like, with threads in parallel rows.

Gelatine stab.—Liquefies, stratiform, with a tough, white, mold-like skin, and, later, with a complete liquefaction and a yellowish scum. The rapidity of liquefaction is very different in our two cultures.

Agar streak.—A luxuriant, whitish-yellow, rough growth, with an irregular, lobate or feathery edge.

Bouillon.—A tough, felted scum, without turbidity or sediment.

Milk.—Rendered alkaline, curdled in three days, and digested, showing a thick, folded scum. In twelve days a translucent surface with a curd below.

Potato.—Luxuriant, white, velvety or powdery dry growth.

Grows at 20° and 37°. Aerobic.

Bact. lactis Michiganii n. s. *A white, spore-bearing Bacterium.* This organism, sent by Marshall, does not agree with any that we have found, although closely allied to the last. The most striking difference is in the colony, but this may be due to the greater vigor of liquefaction. At present, however, we keep it as distinct.

Morphology.—Size, 1.8μ x .9μ, forming chains. Spores developed. Gram stain negative.

Gelatine Colony.—A rapidly liquefying colony, with a uniformly cloudy liquid.

Gelatine stab.—Needle growth beginning to liquefy in one day, infundibuliform; liquefaction complete in three days.

Agar streak.—Spreading widely, moderately thick, wrinkled, opaque, white, not luxuriant.

Fermentation tubes.—No acidity, no gas, no closed arm growth.

Bouillon.—A sediment, turbidity, and a wrinkled pellicle.

Milk.—Alkaline, curdled and completely digested. At 37° slightly pinkish, but not at 20°.

Potato.—Luxuriant, filiform, thick, alveolate, opaque, gray-brown, dry, wrinkled.

Grows better at 37° than at 20°. Aerobic.

Bact. lactis Genevum n. s. *A white, spore-bearing Bacterium*, sent us by Harding.

Morphology.—Size, 3μ–8μ x 1.4μ. No chains. Spores formed chiefly at the ends of the rods. Rods with square ends. Gram stain positive. (One culture negative.)

Gelatine Colony.—A rapidly liquefying colony that may be a smooth liquid mass or may be cloudy. On *litmus gelatine* there may be a wrinkled film. Colony not acid.

Gelatine stab.—A needle growth and a stratiform liquefaction, beginning in one to three days.

Agar streak.—Spreading, thin or raised, smooth, whitish or creamy, moist or sometimes dull, luxuriant.

Fermentation tubes.—No acidity or gas in any sugar bouillon; closed arm growth usually seen. (A slight acidity may appear for a day or two in dextrose, but it then disappears.)

Bouillon.—A sediment, turbidity and pellicle.

Milk.—Is rendered alkaline, curdled and digested completely, with a prominent odor.

Potato.—Spreading, thin or raised, smooth, opaque, cream colored, luxuriant; discolored.

Grows at 20° and 37°. Facultative anaerobic.

Bact. lactis erythrogenes Grotenfeld. *Bacterium with pink fluorescence.* We have several times found bacteria that belong probably to this well known type. None of them produce much red color in milk, although some render it of a pinkish color, and one turned it deep red after several weeks' growth. All of them, except variety D, produce a peculiar pinkish fluorescence in agar. We give below the characters of one of the cultures isolated, with the others as varieties.

Morphology.—Size, 1.2μ x .9μ–1μ. Not forming chains. It forms no spores, stains by the Gram method and shows a capsule.

Gelatine colony.—Round, raised, smooth, homogeneous, entire, translucent, yellowish, shining, later liquefying.

Gelatine stab.—Begins to liquefy in three days, stratiform.

Agar streak.—Filiform, raised, smooth, translucent, flesh color or pink, shining, luxuriant. The agar shows a pink fluorescence.

Fermentation tubes.—Dextrose and saccharose show growth in closed arm, but not lactose. No acidity nor gas produced in any sugar bouillon.

Bouillon.—A flocculent sediment, a membranous pellicle, and a decided turbidity.

Milk.—No change in reaction. The milk may curdle in ten days and begin to digest. The digestion is nearly complete in three weeks and the liquid is of a pinkish color, with a slight odor.

Potato.—A luxuriant growth, white, with discolored potato. There is no pink color shown.

Grows both at 20° and 37°. Facultative anaerobic.

This organism was from a yellow slime on the surface of cheese.

Variety A.—Differs from the above in showing no closed arm growth, a yellowish growth on agar, no curd or digestion in milk, and a scanty growth on potato.

Variety B.—Shows yellow growth on agar. No pellicle on bouillon. Milk becomes alkaline and digests into a red liquid, which later becomes very red. Growth on potato scanty.

Variety C.—Size, .3μ x .5μ–.6μ. No pellicle on bouillon. Milk digests; pinkish. Potato scanty. Growth on agar not yellow.

Variety D.—This fails to produce a pink fluorescence, but has a yellow growth and is wrinkled. The milk is rendered pink, and the growth on the potato is yellow and scanty. This variety is, perhaps, *Bact. erythrogenes* of Dyar (Trans. N. Y. Acad, of Sci., 1895). Probably the same as *Bact. luteum* of Zimmermann. (See p. 142.)

Bact. lactis rubrum. Non spore-bearing, pink Bacterium. This has not been found since its original description in 1899. Its characters, as then given, are as follows:

Morphology.—Size, 2μ–4μ x .9μ. Forming chains. No spores, no capsule.

Gelatine colony.—A bead-formed colony, .7 mm. in diameter, with a granular edge. Liquefies with a nucleus and a clear zone.

Gelatine stab.—A slow liquefier, stratiform, producing a clear liquid with a scum and a sediment.

Agar streak.—Luxuriant, wrinkled, dull orange-yellow or pinkish.

Bouillon.—A sediment, but no pellicle nor turbidity.

Milk.—Becomes alkaline and curdles after several days at 37°. It digests into a dirty liquid.

Potato.—Glistening, smooth, pink or salmon-colored, luxuriant.

Grows at both 20° and 37°.

Variety A.—Found later. Agrees with the above, except that it is of an orange rather than a pink color.

Bact. lactis Burri n. s. *A reddish, bitter milk organism*, described by Burr and Dugelli. As described by them its characters are as follows: (Cent. f. Bac. II., XV., p. 709.)

Morphology.—Size, 1μ–3μ x .7μ. No chains; no spores. Gram stain negative.

Gelatine colony.—Surface colony in a liquefying area, ⅓ mm. in diameter. In fourteen days it is ½ mm. in diameter, of a clear brown color.

Gelatine stab.—Begins to liquefy in four days; infundibuliform.

Agar streak.—Luxuriant, smooth, lobed, reddish.

Fermentation tubes.—No acidity, gas, nor closed arm growth.

Bouillon.—A turbidity, but no sediment nor pellicle.

Milk.—Becomes acid, but does not curdle or digest. It becomes a rusty red, with a cheesy smell and, later, a bitter taste.

Potato.—No growth.

Grows at 20° but not at 37°. Aerobic.

Bact. lactis citronis n. s. *A non spore-bearing, lemon-yellow Bacterium.*

Morphology.—Size, 1μ x .6μ, forming chains. No spores are produced, and no capsules.

Gelatine colony.—Small pits are produced, with a nucleus and a lighter outer zone, which may be variously streaked.

Gelatine stab.—A slow liquefier, producing a cratiform liquefaction, with a dense sediment and a yellow liquid. At first clear, but later cloudy.

Agar streak.—A luxuriant, thick, folded growth, at first greenish-yellow, and later lemon-yellow.

Bouillon.—A turbidity and a sediment.

Milk.—Becomes alkaline and digested into an amber-colored or pale yellow liquid. Sometimes it curdles before digestion.

Potato.—Thick, smooth, flesh-colored, and later lemon-yellow; or sometimes lemon-yellow from the start.

Grows at both 20° and 37°. Aerobic.

Variety A.—This variety, also found in milk in Middletown, agrees with the above in most respects, differing in the following points: Size, $3\mu \times 1.5\mu$. Spores are produced. The gelatine forms a pit full of threads. Milk is curdled and after digestion shows a clear liquid and tenacious scum. The potato growth is wrinkled.

Variety B.—This organism forms no chains nor spores. Its colony is lemon-yellow, even when viewed under the microscope, a very unusual character; later it liquefies and sends processes into the gelatine. Its gelatine stab is infundibuliform, or a dry pit. Its growth on agar is lemon-yellow and very thin.

It is doubtful whether these three varieties should be grouped together, and certainly they should not if it is true that two of them do not form spores. We have lost these cultures and are unable to verify the characters above given. Therefore we insert them in their original form.

Bact. lactis minutissimum. A very slender, orange Bacterium. We have not fouud this since the original description in 1899. The following are the characters as then described.

Morphology.—Size, $1.5\mu \times .4\mu$. Forming long chains, and not producing spores.

Gelatine colony.—Surface colony irregulary branching; deep colonies burr-like, with a yellow centre and irregular processes, or sometimes simply lobed. Rays extend from a liquefying pit into the gelatine.

Gelatine stab.—Begins to liquefy in two days with an infundibuliform or cratiform liquefaction, and a brilliant yellow sediment.

Agar streak.—A luxuriant, widely spreading, orange growth, covering the whole surface.

Bouillon.—A sediment, turbidity and a pellicle.

Milk.—Rendered alkaline and becomes somewhat thick and dark colored, but no visible digestion.

Potato.—Luxuriant, deeply orange.

Grows better at 20° than at 37°. Aerobic.

Variety A.—A second culture, found later, may be a variety of the same, although it is not so small. It is $.6\mu$ in diameter, and does not appear to form chains. Its colony is brilliant yellow, smooth and translucent, but does not show the irregular processes. Milk does not become thick. The color on potato is bright yellow rather than orange.

Bact. lactis Marshalli n. s. *A slimy milk, yellow Bacterium.* This is the organism with which Marshall has worked and which was shown by him to have a hastening action upon lactis bacteria (Cent. f. Bact. II.). The following characters were determined by us from cultures sent by him, and agree essentially with those determined by him:

Morphology.—A rod, not forming chains. Size, $1.2\mu \times .3\mu$. (Marshall's measurements, 1.7μ–$5.25 \times .8\mu$–$.875\mu$.) It produces no spores, has no capsules and Gram stain is negative.

Gelatine colony.—A slowly liquefying, granular colony, which may later become large, irregular and slimy.

Gelatine stab.—Begins to liquefy in two to three days, infundibuliform. In nine days it liquefies ¼ inch. Upon *litmus gelatine* it forms a rough, red-brown colony, with a dark center. Not acid.

Agar streak.—A luxuriant, viscous colony, filiform, raised, smooth, cream-white or gray, but later lemon color.

Fermentation tubes.—No acidity, gas, nor closed arm growth in any bouillon.

Bouillon.—A sediment and turbidity, and a pellicle formed around the edges of the tube.

Milk.—Becomes alkaline and digests, but does not normally curdle. Has a prominent odor, and is slimy.

Potato.—A luxuriant, filiform, effused, smooth, lemon-yellow growth.

Grows both at 20° and 37°. Aerobic.

We have found essentially the same organisms in Middletown, and Harding has sent us one from New York which failed to digest milk, but agreed in other respects. This latter one may, perhaps, be called *variety A*.

Variety B.—An organism isolated from Camembert cheese, sent us direct from France, really belongs here, although differing in the following characters: Its colony is white. It is not viscous. It forms no pellicle. It does not digest milk. Its growth on potato is orange. We have found the same on Camembert cheese from New York markets.

Bact. lactis Limburgii n. s. *A non spore-bearing, orange-yellow Bacterium*, This organism was isolated from milk and described by Burri and Dugelli as follows. (The name is our own):

Morphology.—Size, 1.5μ–3μ x .5μ. Forming no chains and no spores.

Gelatine colony.—A round, brownish colony, 1 mm. in diameter. After six days a yellow disk is seen in its cloudy liquid.

Gelatine stab.—A needle growth and a surface growth, but after six days liquefaction begins; stratiform.

Agar streak.—Luxuriant, smooth, glistening, dirty yellow.

Fermentation tubes.—Not described, but no acidity is produced, and probably no gas in sugar bouillons.

Bouillon.—Liquid becomes turbid, but shows no pellicle.

Milk.—No change in reaction, and no curdling. The milk becomes digested and has a Limburger smell.

Potato.—Scanty yellow, glistening. Potato not discolored.

Bact. lactis luteum. This name was given by Zimmerman (Cent. f. Bac. II., XI., p. 200,) to a type isolated by him from the udder. Several of our cultures agree with it as closely as can be determined from his incomplete descriptions. It agrees closely with *Bact. erythrogenes*, except in lacking a pink fluorescence, and in not making milk red or pink. The characters given below are from our own cultures, to which we have given Zimmerman's name. We have found the organism in Camembert cheese from the markets, probably imported from France.

Morphology.—A rod, forming no chains. Size, 1.2μ x .8μ. No spores no capsules. Gram stain positive.

Gelatine colony.—A slowly liquefying colony, with a dense central growth and a clear liquid.

Gelatine stab.—A slow liquefaction; crateriform.

Agar streak.—A luxuriant, filiform, raised, rugose, lemon-yellow growth; dull and wrinkled.

Fermentation tubes.—No gas, no acidity, and no closed arm growth in any bouillon.

Bouillon.—A sediment, membranous pellicle and a slight turbidity.

Milk.—Becomes alkaline, but no other visible change.

Potato.—A luxuriant, spreading, thick, contoured growth, opaque, white or brownish-yellow.

Grows at 20° and 37°. Aerobic.

The color of this organism varies from a brilliant yellow to a dull yellow. Some cultures do not appear to grow on potato and show a slight digestion of milk.

Variety A.—One culture we regard as distinct enough to be recognized as a variety. It was obtained from milk rather than from cheese. Its size is .8μ x .3μ, and it does not stain with Gram. Its colony is round, moderately thick, smooth and yellow, and then forming a pit. Upon *litmus gelatine* it is pale and thin. It produces no pellicle on bouillon, but curdles and digests milk, turning it slightly yellow. Its growth on potato is dry, luxuriant and lemon-yellow.

Bact. lactis Ashtonii n. s. *A non spore-bearing, yellow Bacterium.*

Morphology.—Size, 1.2μ–3.5μ x 1.2μ. No chains, no spores nor capsules. Gram stain irregular.

Gelatine colony.—A slow, liquefying pit, with a cloudy liquid, tinged with yellow, *litmus gelatine* is not acid.

Gelatine stab.—A needle growth and a napiform liquefaction, beginning in three days.

Agar streak.—Filiform, raised, smooth, yellow, moist, viscous.

Fermentation tubes.—No acidity or gas in any bouillon, closed arm growth in all. (Saccharose is slightly acid after several days.)

Bouillon.—Sediment, turbidity and pellicle.

Milk.—Is rendered alkaline, curdled and digested completely, with a yellowish surface and a strong odor.

Potato.—Filiform raised, smooth, yellow, luxuriant; no discoloration.

Grows at 20° better than at 37°. Facultative anerobic.

Bact. lactis album n. s. *A white, liquefying Bacterium, not acid.* Found in the udder at Storrs. It may be the same as *Bact. luteum*, without pigment. Its characters are as follows:

Morphology.—Rods, forming no chains. Size, 1μ–3μ x .7μ–.9μ. It forms no spores, no capsules, and Gram stain is positive.

Gelatine colony.—A very slowly liquefying colony, not characteristic; sometimes the gelatine dries before liquefaction takes place.

Gelatine stab.—Begins to liquefy in three days, and is about ⅓ liquefied in twenty-one days. Napiform and stratiform.

Agar streak.—Filiform, raised, smooth, opaque, cream-white, shining, luxuriant, viscous.

Fermentation tubes.—No acidity, gas, nor closed arm growth.

Bouillon.—A sediment, turbidity and pellicle.

Milk.—Becomes alkaline, is curdled, or sometimes digests without curdling. The digested milk is very slimy and of a slight straw color (in one culture, pink).

Potato.—A very abundant, spreading, convex, smooth, brown growth; potato discolored.

Grows at 20° and 37° abundantly. Aerobic.

Variety A.—An organism found in the pink slime on Camembert cheese closely resembles this, but differs in the following: It is not viscous on agar, nor does it make milk slimy. It produces no pellicle in bouillon, and neither curdles nor digests milk.

II. Acid in dextrose or other sugars.

Bact. lactis musci. An arborescent bacterium with myceloid colonies. This was found in milk in Middletown, in cheese, and one culture was sent from Kiel isolated from Mazoon. Perhaps identical with *Bact. mycoides* (Flügge).

Morphology.—Long filaments made up of rods 3μ x 1μ. Central spores no larger than the rods. Gram stain positive.

Gelatine colony.—Myceloid, branching, radiating colonies before liquefaction. Commonly forming a thin, white, velvety, or ground-glass surface upon the liquefying gelatine. *Litmus gelatine* is not acid.

Gelatine stab.—There is at first an arborescent needle growth, but liquefaction begins in one day, and a wrinkled glass-like surface is formed.

Agar streak.—Luxuriant, thin, white, wrinkled. In one culture threads grow down into the agar, and the agar turns dark colored.

Fermentation tubes.—Growth is somewhat variable. In one culture dextrose is rendered acid with a closed arm growth in all sugar bouillons. In another culture dextrose and saccharose are acid, and there is no closed arm growth. No gas.

Bouillon.—A turbidity, sediment and pellicle, except in one culture where the pellicle is wanting.

Milk.—Curdles with amphoteric reaction and subsequently completely digested.

Potato.—Luxuriant, thin, whitish, sometimes wrinkled; potato may be discolored.

Grows at 20° and 37°. Aerobic.

Variety A.—One culture was sufficiently different to be separately tabulated. The differences are as follows: Size, 2.5μ x 1.4μ. Gram stain negative. The gelatine colony shows masses of bacteria hanging together. They are arborescent under mica. A dry pit formed in gelatine stab. Agar growth not wrinkled. No closed arm growth. The reaction of milk is alkaline. Here belong Nos. 14 and 16 of Adametz.

Bact. lactis cretaceum n. s. *A non-arborescent, spore-bearing Bacterium.*

Morphology.—Size, 3–5μ x 1.4μ. No chains nor capsules. The Gram stain is positive. Spores are produced, no larger than the rods.

Gelatine colony.—Not characteristic; a rather slowly liquefying pit forms, without any distinguishing marks. In *litmus gelatine* it is not acid.

Gelatine stab.—No needle growth. In one day it begins to liquefy; stratiform or sometimes infundibuliform.

Agar streak.—Filiform, raised, smooth, cretaceous, white or flesh-colored, moist, luxuriant.

Fermentation tubes.—Acidity and closed arm growth in dextrose and saccharose; closed arm growth, but not acid in lactose. No gas.

Bouillon.—A sediment, a slight turbidity and, later, a slight pellicle.

Milk.—Becomes alkaline, curdles promptly and completely digests, with a prominent odor.

Potato.—Spreading, raised, smooth, cretaceous, white, luxuriant; potato discolored.

Grows at 20° and 37°. Facultative anaerobic.

Bact. lactis lobatum n. s. *An orange, acid liquefier.* This organism was found in stable dust and in milk direct from the udder. The two cultures differ slightly in color and bouillon growth.

Morphology.—Size, .8μ–1μ x .5μ. No chains, no spores, no capsules. Gram stain positive.

Gelatine colony.—A round, raised, smooth homogeneous colony, sometimes yellowish, with a lobate center and a clear ring when liquefying. *Litmus gelatine* shows an acid, liquefying colony.

Gelatine stab.—Slow liquefier, at first saccate, and then stratiform. The liquid is cloudy.

Agar streak.—A smooth, raised, thin, orange-colored colony, luxurious.

Fermentation tubes.—All three sugars are rendered acid, and there is growth in the closed arm, but no gas.

Bouillon.—A sediment, turbidity, and pellicle. In one culture there is no pellicle.

Milk.—Rendered acid, but not curdled. It is digested and turned amber-color or reddish, with a jelly-like sediment.

Potato.—Thick, opaque, orange-colored, luxurious.

Grows well at 20°, hardly at all at 37°. Facultative anaerobic.

Bact. lactis cloacae n. s. This organism appears much like *B. cloacae* of Jordan, differing slightly in its growth in bouillon and on potato. Its liquefying power is also less. It was found only once in milk, in Middletown.

Morphology.—Size, .7μ–.8μ x 5μ. No chains, no spores. Gram stain negative. It shows a capsule.

Gelatine colony.—A round, thick, smooth, homogeneous colony, 1 mm. in diameter; white, acid on *litmus gelatine.*

Gelatine stab.—A dry pit is first formed, which later liquefies, infundibuliform.

Agar streak.—A narrow, raised, smooth growth; opaque, whitish, dull, fairly luxuriant.

Fermentation tubes.—Acidity, closed arm growth and gas in all sugars.

Bouillon.—A sediment and turbidity, but no pellicle.

Milk.—Acid and curdled, showing a clear whey, but there is no visible digestion. A sour odor.

Potato.—A scanty, white growth, with a discolored potato.

Grows at 20°, and moderately at 37°. Aerobic.

Bact. lactis liquaerogenes n. s. *A gas-producing, liquefying Bacterium.*

Morphology.—Size, 1μ–1.6μ x .7μ. No chains, no spores, and Gram stain negative.

Gelatine colony.—A non-characteristic, rapidly-liquefying colony.

Gelatine stab.—Begins to liquefy in two days; complete in nine days.

Agar streak.—Not luxuriant, spreading, thin, smooth, white.

Fermentation tubes.—Dextrose and saccharose show acidity, gas and closed arm growth. Lactose shows closed arm growth but no acidity or gas.

Bouillon.—A turbidity, sediment and a pellicle.

Milk.—Is curdled without change of reaction, and is digested with an odor of Brie cheese.

Potato.—Not luxuriant, spreading, smooth, thin, white; potato discolored.

Grows at 20° and 37°. Facultative anaerobic.

Bact. visco fucatum Harrison and Barlow. *A slimy milk Bacterium with blue pigment.* This organism, isolated and described by Harrison and Barlow, from oily butter, seems to be new. (Trans. R. S. of Canada, XI., 1905–6.) It was not the cause of the oiliness of the butter, but is peculiar in showing a wide range of color. Its characteristics are given below in condensed form.

Morphology.—Size, 1μ–1.8μ x .6μ–.9μ. No long chains, no spores. Gram stain positive, and an evident capsule. Branched involution forms in all cultures.

Gelatine colony.—A slimy colony, yellowish-green, with crystals in the gelatine. When carbohydrates are present, the gelatine is blue or green.

Gelatine stab.—Liquefies in ten days, complete in two months; cratiform. The liquid is of a dark inky color above and rusty below.

Agar streak.—A slow, smooth growth, viscous, no pigment.

Fermentation tubes.—Not stated, but probably acid without gas.

Bouillon.—A sediment and turbidity, but no pellicle. The liquid is alkaline, slimy.

Milk.—Rendered acid and curdled after several days; later digested, with a greenish-blue color, and becomes slimy.

Potato.—Yellowish-white, slimy, luxuriant. The potato becomes light-blue and, later, amber-colored.

Grows at both 20° and 37°. Aerobic.

Bact. lactis brevis n. s. *A white liquefier.* This has been found several times in milk and cheese here and elsewhere. It seems to be identical with one sent by Freudenreich and is apparently a widely distributed species.

Morphology.—Size, .7μ–.9μ x .5μ–.6μ. No chains, no spores. Gram stain irregular; no capsule.

Gelatine colony.—A round, thin colony, lobed, whitish. It may show acidity in *litmus gelatine*, and it slowly liquefies.

Gelatine stab.—Begins to liquefy in from one to two days, and may be completely liquefied in from three to twelve days. Stratiform.

Agar streak.—Fairly luxuriant, smooth, white, not characteristic.

Fermentation tubes.—All three sugars are acid, and there is usually growth in the closed arm, but no gas.

Bouillon.—A sediment, but no turbidity, and no pellicle.

Milk.—Rendered acid and curdled, and later, is partly digested.

Potato.—Barely visible; thin and white.

Grows at 20° and 37°. Facultative anaerobic.

Found many times, the numerous varieties showing some differences. The Freudenreich organism is longer, 1μ in length. It makes milk acid and bitter. This is apparently *Milch. Bacterium II.* of Koning (Milchw. Zent. II., p. 317, 1906).

Variety A.—This organism, sent by Harding, differs in the following points: Size, 2–3μ x 1.2μ. Liquefaction of gelatine tube never complete. A pellicle in bouillon. Rather more luxuriant on potato.

Bact. lactis fluorescens n. s. *A fluorescent Bacterium.* This organism, being non-motile, seems to be different from the common fluorescent form. We have found it but once, in New York city milk. It may be only a non-motile variety of *B. fluorescens*, but we have been unable to detect any motility in our cultures.

Morphology.—Size, 1.4μ–2.5μ x .7μ–.9μ. No chains, no spores, no Gram stain and no capsule.

Gelatine colony.—A slow liquefier, forming a peculiar lace-like colony in a pit, with a dense centre.

Gelatine stab.—A needle growth, stratiform; liquefaction beginning in one day.

Agar streak.—Filiform, capitate, smooth, translucent, white, luxuriant, with a green fluorescence.

Fermentation tubes.—Dextrose and saccharose are rendered acid; lactose is not; no closed arm growth; no gas.

Bouillon.—A sediment, turbidity and a pellicle.

Milk.—Rendered alkaline and curdled at 20°, but not at 37°. Digestion occurs later and the milk has a strong odor.

Potato.—A filiform, raised, smooth, white, luxuriant growth.

Grows at 20° and only slightly at 37°. Aerobic.

Bact. lactis plicatum n. s. *A non-acid, white, liquefying Bacterium.* Isolated from milk by Harding.

Morphology.—Size, 3μ–5μ x .8μ–.9μ, growing in long chains. No spores, no capsules, and Gram stain irregular.

Gelatine colony.—A slow liquefying colony, showing a peculiar folding.

Gelatine stab.—A needle growth, beginning to liquefy in one day, and about half liquefied in ten days; infundibuliform.

Agar streak.—Filiform, thick, smooth, opaque, whitish, moist, moderately luxuriant.

Fermentation tubes.—All three sugar bouillons are slightly acid, but there is no closed arm growth, and no gas.

Bouillon.—A sediment and slight turbidity, but no pellicle.

Milk.—Rendered alkaline, curdled in three days and subsequently digested.

Potato.—Spreading, thick, mottled, wrinkled, white, luxuriant, with discolored potato.

Grows at 20° and 37°. Aerobic.

Variety A.—Differs in the following points: No chains observed. Colony without the peculiar folding. Digestion of milk not noticeable. Growth on potato scanty and not wrinkled.

Bact. lactis Gorinii n. s. *A non-acid, white, liquefying Bacterium.* The original of this organism was sent from Italy by Gorini. Two very similar cultures were found by us, one in New York and one in Connecticut. The original culture had the following characters:

Morphology.—Size, 1.5μ–2.5μ x 1μ. Rods with square ends. No chains, no spores. Gram stain positive.

Gelatine colony.—A slow liquefier, producing a large pit with irregular mottled clusters of bacteria.

Gelatine stab.—Begins to liquefy in two days and is ¾ complete in three weeks. Infundibuliform.

Agar streak.—Spreading, raised, smooth, opaque, white, moist, luxuriant, viscous.

Fermentation tubes.—Dextrose and saccharose are acid; lactose not acid. No closed arm growth; no gas.

Bouillon.—A sediment, turbidity, and a pellicle.

Milk.—Made strongly alkaline, curdled and completely digested at 20°.

Potato.—Spreading, thick, smooth, opaque, moist, luxuriant; potato discolored.

Grows well at 20° and 37°. Aerobic.

Variety A.—Isolated from milk in Connecticut. Is not quite so large. Gram stain negative. Saccharose is not acid. Produces iridescent brown color. Does not grow well at 20°. Milk has a peculiar color.

Variety B.—(From milk in New York city.) Saccharose is acid. There is no pellicle on bouillon. No digestion of milk. Growth on potato is scanty.

Variety C.—(From Brie cheese.) Has a simple, granular, rapidly-liquefying colony. Shows growth in closed arm of fermentation tubes, and a pellicle on bouillon. The milk develops the odor of Brie cheese.

Varieties A and B are probably cultures of the same organism, one of which is more vigorous than the other. Here evidently belongs *Bact. C.* of Müller (Arch. f. Hyg. LXVII., p. 127), which agrees in all points, but shows a blue fluorescence in gelatine, and gas in dextrose bouillon.

Bact. lactis magnum n. s. *A non-acid, white, liquefying Bacterium.*

Morphology.—Size, 3μ x 1.5μ. Chains produced; no spores or capsules. Gram stain positive. Rods with square ends.

Gelatine colony.—A fairly rapidly liquefying pit, which may be filamentous and with ciliated edge. On *litmus gelatine* it is not acid.

Gelatine Stab.—A needle growth, which may be arborescent and later liquefying; stratiform. Liquefaction begins in one to three days; complete in three weeks.

Agar streak.—Filiform or spreading, thick, punctate, opaque, white, moist, luxuriant.

Fermentation tubes.—Acid in dextrose only. No closed arm growth and no gas.

Bouillon.—A sediment, a turbidity, and a pellicle.

Milk.—Becomes alkaline, curdles after three days and digests into a brownish liquid, and a prominent odor.

Potato.—Spreading, thick, contoured, translucent, white; potato discolored.

Grows at 20° and 37°. Aerobic.

Bact. lactis flocculus n. s. *An acid, non-curdling, liquefying Bacterium.* From Camembert cheese.

Morphology.—Size, 1μ–2μ x 1μ. No chains, no spores. Gram stain positive.

Gelatine colony.—A slowly liquefying colony, which is lobate or moruloid.

Gelatine stab.—A needle growth and a surface growth, which begins to liquefy in ten days.

Agar streak.—A filiform, raised, smooth, opaque, white colony, rather scanty.

Fermentation tubes.—Dextrose is acid, but no other sugar bouillon. No closed arm growth, no gas. One culture is acid in all sugars.

Bouillon.—A sediment, turbidity, and a pellicle. One culture shows no growth.

Milk.—Acid but not curdled, and shows no digestion. Has a prominent odor.

Potato.—Spreading, thin, contoured, white, moist, luxuriant; potato discolored.

Grows better at 20° than at 37°. Aerobic.

THE GENUS PSEUDOMONAS.

I. Non-liquefying.

Ps. lactis Middletownii n. s. *A Pseudomonas, producing gas, but no acidity.*

Morphology.—Size, 1.4μ x .8μ–.9μ. No chains, no spores, no capsules. Gram stain negative.

Gelatine colony.—A round, raised, smooth, gyrose, entire, gray-white colony. On *litmus gelatine* the colony is coarsely granular, looking like a colony of yeast.

Gelatine stab.—A dry pit is formed, with needle growth.

Agar streak.—Filiform or spreading, smooth, thin, gray-white, moderately luxuriant, moist.

Fermentation tubes.—No acidity in any sugar bouillon, but closed arm growth and gas produced in all.

Bouillon.—A sediment, turbidity and a pellicle.

Milk.—Rendered acid and curdled after several days, and subsequently slightly digested.

Potato.—A luxuriant, spreading, thick, gray-white growth; potato discolored.

Grows at 20°, but hardly at all at 37°. Aerobic, or facultative anaerobic.

Ps. fluorescens aurea Weigmann. *A fluorescent, non-liquefying Pseudomonas.* This culture was sent me by Weigmann, but had lost its fluorescent character when received by us. Its characteristics, as given below, were made in our laboratory. This is perhaps *Ps. convexa* of Wright. We have several times found a similar organism in milk, but unfortunately at the time we did not make a study of their flagella; but we have no doubt that they belong with this organism of Weigmann. We list one of our own organisms as variety A.

Morphology.—Size, 2.5μ x .9μ. Short chains. There are no spores nor capsules and the organism does not accept the Gram stain. [Our organisms were usually shorter.]

Gelatine colony.—A round, raised, contoured, grumose colony, of a brownish-red color. [A green halo around the colony is common.] On *litmus gelatine* it is much folded.

Gelatine stab.—A filiform, needle growth and a raised, surface growth. [The surface growth is thick, and the gelatine may show a green color.]

Agar streak.—A filiform, smooth, thin growth of a yellowish color, moderately luxuriant. It was probably originally fluorescent, but this character has been lost. Our own cultures always showed the fluorescence.

Fermentation tubes.—No acidity, gas, nor closed arm growth in any sugar bouillon.

Bouillon.—A red sediment, a ring-like pellicle, and slight turbidity are formed. [Greenish.]

Milk.—Rendered slightly alkaline, or there is no change in the reaction. No curdling nor digestion occurs, and there is no change in color.

Potato.—A filiform, raised, contoured growth, of a brownish-yellow to an orange color; luxuriant, and with the potato discolored. [Yellow to brown, and sometimes folded.]

Grows at both 20° and 37°. Aerobic.

Variety B.—Isolated from milk here, is a similar, non-liquefying fluorescent monotrich, which we regard as the same. It is quite common and agrees closely enough with the above to be called by the same name. It commonly makes the gelatine green, and has a strong fluorescent action on agar. Milk is also turned green, but is otherwise unchanged. On agar the growth is rather scanty, but is luxuriant on potatoes, of a brown color to white. On potato it may be folded.

Ps. lactis Estenii n. s. *A Pseudomonas with a smoky fluorescence.* This organism is quite common in milk. Another one practically identical agrees in all points except that it does not produce the smoky fluorescence.

Morphology.—Size, .8μ–1.2μ x .4μ. No chains are formed, no spores nor capsules, and the organism does not accept the Gram stain.

Gelatine colony.—A round, smooth, capitate, contoured, homogeneous colony, of a cream-white to a gray color. On *litmus gelatine* it forms a pale, thin surface colony.

Gelatine stab.—A filiform, needle growth, and a raised, dry, not spreading, surface growth.

Agar streak.—Filiform, raised, smooth growth, translucent; gray in color; luxuriant and slightly viscous. The agar becomes smoky.

Fermentation tubes.—No acidity, gas, nor closed arm growth in any sugar bouillon.

Bouillon.—A sediment and flocculent turbidity are formed, but no pellicle.

Milk.—No action on milk.

Potato.—A filiform, thin, smooth growth; gray in color; moderately luxuriant.

Grows both at 20° and 37°. Aerobic.

Variety B differs from A in being slightly larger, 1.8μ–3μ x .7μ, and in producing no fluorescence.

Ps. lactis filiformis n. s. *A yellow, non-liquefying Pseudomonas.* Found once in New York milk.

Morphology.—Size, 2.5μ–3.5μ x .8μ–.9μ. No capsule, and no Gram stain. Spores are produced which are frequently seen as long chains. One long flagellum.

Gelatine colony.—A round, convex, smooth, entire colony of a creamish or yellow color. On *litmus gelatine* the colony is red-brown, non-acid.

Gelatine stab.—A filiform needle growth, and a flat surface.

Agar streak.—A filiform, raised, smooth, yellowish growth, not very luxuriant, moist.

Fermentation tubes.—Dextrose and saccharose bouillons are rendered acid. There is no gas nor growth in the closed arm in any bouillon.

Bouillon.—A sediment, a ring-formed pellicle, and a flocculent turbidity.

Milk.—Rendered acid, but no other change produced.

Potato.—A beaded, thick, punctate growth, of a yellow color, not very luxuriant. Potato discolored.

Grows better at 20° than at 37°. Aerobic.

Ps. pseudo tuberculosis Klein. This organism, isolated by Klein from London milk, was sufficiently well described by him to be inserted here as follows:

Morphology.—A rod, forming long chains; individual elements 1.2μ–1.8μ x .4μ–.5μ. Gram stain positive. No spores nor capsules described.

Gelatine colony.—A white surface colony, somewhat granular, and resembling that of *B. coli.* No gas is produced, however.

Agar streak.—Resembles *B. coli*, but is less luxuriant.

Fermentation tubes.—Not described but, doubtless, no acidity nor gas is produced.

Bouillon.—A turbidity and a slight pellicle, but no sediment.

Milk.—No action on milk.

Potato.—A thin, crenate, faintly brownish growth, with a whitish-yellow margin.

This is found in 8% of London milk, and is said to be pathogenic for Guinea pigs.

Ps. lactis viridis n. s. *A Pseudomonas, turning gelatine green.* This organism has been found only once, in milk from Colchester.

Morphology.—Size, .9μ–1μ x .4μ–.5μ. Spores are produced, and there is no capsule. There are no chains, and the Gram stain is negative.

Gelatine colony.—A round, raised, smooth, homogeneous colony, entire, yellowish, moist.

Gelatine stab.—A needle growth with raised surface. The gelatine is turned green.

Agar streak.—A filiform, raised, smooth, translucent, white growth, quite luxuriant, moist; no fluorescence.

Fermentation tubes.—Dextrose rendered acid and shows growth in closed arm. There is no gas. In the other sugar bouillons there is no acidity, gas, nor closed arm growth.

Bouillon.—A flocculent sediment, a pronounced turbidity, but no pellicle.

Milk.—Very slightly acid, but no further change.

Potato.—A filiform, thin, smooth, creamish-colored, moist growth; not very luxuriant. Potato discolored.

Grows at both 20° and 37°. Facultative anaerobic.

Ps. sapolactica Eichholz. *An acid, non-liquefying Pseudomonas* (soapy). This organism was sent by Weigmann and was stated by him to produce soapy-tasting milk. When studied by us this latter character was not apparent. We have found an identical organism (not soapy) in New York city milk, and twice in Middletown. The Middletown culture was found in great quantities in some milk that had been preserved at 1° for several weeks. A very closely allied organism was sent us from Geneva by Harding, which we have called variety A.

Morphology.—Size, .8μ–1.7μ x .7μ–.8μ. No chains, no spores, no capsules. Gram stain negative.

Gelatine colony.—A round, raised, smooth, homogeneous, entire colony, of a gray color. In *litmus gelatine*, in some cases, the colony becomes acid.

Gelatine stab.—A filiform needle growth, and a flat surface.

Agar streak.—Filiform, thick, smooth, opaque, white, moist, moderately luxuriant.

Fermentation tubes.—Dextrose only is rendered acid. There is no gas or closed arm growth in any sugar bouillon.

Bouillon.—A sediment, decided turbidity, and a ring-like pellicle.

Milk.—Is rendered alkaline, at least after several days, but there is no other change.

Potato.—A slight growth, linear, thin, contoured, brownish in color, moist. Potato not discolored.

Grows rather better at 37° than at 20°. Aerobic.

Variety A.—Is acid in all three sugar bouillons, curdles milk and shows no potato growth.

II. Liquefying.

Ps. lactis anana n. s. This was originally described in 1899. Several cultures from milk in Middletown, and New York, and Storrs, have been found agreeing with this in all points except in the presence of the banana smell upon potato. The following more complete description was from a culture isolated more recently from milk in Middletown:

Morphology.—Size, .8μ–1.2μ x .5μ. Forms chains, no spores and no capsules. Gram stain negative.

Gelatine colony.—A very rapid liquefier, producing a granular pit; not characteristic.

Gelatine stab.—Liquefies rapidly; either stratiform or infundibuliform.

Agar streak.—Spreading, flat, smooth, creamish to brown color, rather luxuriant, and sometimes slightly viscous.

Fermentation tubes.—No acidity nor gas in any sugar bouillon. One culture showed growth in the closed arm, but the others did not.

Bouillon.—A granular sediment, and a decided flocculent turbidity, but no pellicle. The liquid is sometimes but not always greenish.

Milk.—Is curdled without change in the reaction, or slightly alkaline, and is afterwards digested. After digestion it is colorless and transparent, and sometimes jelly-like. It may have a greenish tinge.

Potato.—A luxuriant growth, widely spreading, convex, smooth and moist, of a brownish color. Potato not discolored.

Grows at both 20° and 37°. Aerobic.

Probably the culture that produces the green color deserves to be called a distinct variety.

Ps. lactis Eurotas n. s. *A brown, fluorescent, liquefying Pseudomonas.* This organism has been found in milk directly from the udder and in New York city milk, the latter differing from our organism in the points indicated by brackets.

Morphology.—Size, .9μ–1.5μ x .3μ. No chains, no spores, no capsules, and Gram stain negative.

Gelatine colony.—A round, convex, smooth, punctate, entire colony, of a gray-brown color. On *litmus gelatine* it is alkaline and slowly liquefies.

Gelatine stab.—Liquefaction is slow; stratiform.

Agar streak.—A luxuriant growth, linear, flat, smooth, gray [yellow], moist. The agar shows an amber-colored fluorescence.

Fermentation tubes.—All three bouillons are rendered alkaline, and show closed arm growth, but no gas.

Bouillon.—A sediment, a decided turbidity, and a flocculent pellicle.

Milk.—Is rendered alkaline, is curdled both at 20° and 37°, and is completely digested. [The milk does not curdle.]

Potato.—A luxuriant, linear, smooth growth, of a brown color [yellowish].

Grows at both 20° and 37°. Facultative anaerobic.

Ps. lactis nigra Gorini. *A black pigment forming Pseudomonas.* This organism was received from Gorini, and the characters as given below were determined by him. It clearly resembles *B. lactis niger A.*

Morphology.—Size, 2μ–3.5μ x 1μ. No chains, no spores, no capsules. Gram stain negative.

Gelatine colony.—A pit, liquefying slowly, and with an irregular centre.

Gelatine stab.—Liquefaction begins in twelve hours; infundibuliform.

Agar streak.—A filiform, raised, rugose growth; opaque, cream-white. Luxuriant, with a dull surface, and sometimes wrinkled. The agar shows a brown fluorescence.

Fermentation tubes.—No acidity nor gas in any sugar bouillon. A very slight growth in the lower quarter of the closed arm.

Bouillon.—A sediment and slight turbidity, with a wrinkled pellicle, which may sink in flakes to the bottom.

Milk.—Rendered acid, curdled, and subsequently digested. The digestion is complete and a slight sliminess is produced.

Potato.—Luxuriant, spreading, convex, smooth, grayish-brown. Potato chocolate-colored.

Grows well at 20° and 37°. Aerobic.

Ps. lactis contorta n. s. *A polypiform, spore-bearing, monotrich.* This organism has been found only once, in milk from New York.

Morphology.—Size, 1–5μ x .8μ. It apparently produces spores and has a single flagellum, although it was lost before the study was completed.

Gelatine colony.—A slow, liquefying pit, at first umbonate. On *litmus gelatine* it is highly lobed and contorted, and does not liquefy in four days.

Gelatine stab.—A filiform needle growth, with a flat surface growth, which later becomes a dry pit. True liquefaction does not appear.

Agar streak.—A moderate growth, filiform, convex, smooth, opaque, of a cream-white color.

Fermentation tubes.—No acidity nor gas in any sugar bouillon, but growth in closed arm.

Bouillon.—A sediment, slight turbidity, and a granular pellicle.

Milk.—Rendered alkaline, but not curdled. At 20° there is a slight digestion and the milk is slightly slimy.

Potato.—Luxuriant growth, filiform, convex, smooth, opaque, of a gray color.

Grows better at 20° than at 37°. Facultative anaerobic.

Ps. lactis minuta n. s. *A very small spore-bearing monotrich.* This organism has been found only once, in milk directly from the udder.

Morphology.—Size, .6μ–.8μ x .3μ. A very short rod, not forming chains. No spores, no capsules. Gram stain positive.

Gelatine colony.—Round, raised, smooth, entire colonies, of a brownish-yellow color, which, later, liquefy.

Gelatine stab.—A slow liquefaction, crateriform.

Agar streak.—Luxuriant, filiform, raised, translucent, porcelain-white, moist.

Fermentation tubes.—No acidity, gas, nor closed arm growth in any sugar bouillon.

Bouillon.—A flocculent sediment and a slight turbidity, but no pellicle.

Milk.—Rendered acid, is not curdled or digested, and no other change is noticeable.

Potato.—No visible growth.

Grows at both 20° and 37°. Aerobic.

Ps. lactis mina n. s. *A Gram-staining, spore-bearing, monotrich.* This organism has been found only once, in New York city milk. It is somewhat similar to the last, but differs in some important points.

Morphology.—Size, 1.4μ–1.8μ x .6μ. A slender rod. No spores, no capsules. Gram stain negative.

Gelatine colony.—A slow liquefying pit, or sometimes a dry pit without liquefaction, but with a dense colony at the bottom.

Gelatine stab.—No true liquefaction, but a deep, dry pit is formed.

Agar streak.—A luxuriant growth, filiform, raised, smooth, opaque, white, moist.

Fermentation tubes.—No acidity, gas, nor closed arm growth in sugar bouillon.

Bouillon.—A granular sediment and decided turbidity, with a membranous pellicle.

Milk.—No change except a slight alkalinity.

Potato.—A nodose, convex, contoured growth, gray in color, moist, and not luxuriant. The potato is discolored.

Grows better at 20° than at 37°. Aerobic.

Ps. lactis Robertii n. s. *A white, non-acid, liquefying monotrich.* This organism was found in Middletown and New York city milk. A second variety, found at Storrs, differed in points shown in brackets.

Morphology.—Size, 2μ x .7μ-.9μ [1μ x 3μ]. Large rods with square ends. No chains. Gram stain positive. No capsules and no spores.

Gelatine colony.—A rapidly liquefying colony, with a greenish-orange pigment. [Brownish.]

Gelatine stab.—A rapid liquefier, stratiform, with a clear yellow liquid. [Slow liquefier.]

Agar streak.—Luxuriant, raised, smooth, moist, white. [Dry and wrinkled.]

Fermentation tubes.—No acidity or gas in any bouillon, but growth occurs in closed arm in all cases.

Bouillon.—A sediment, decided turbidity, and membranous pellicle.

Milk.—Rendered alkaline, curdled and digested. It has an odor and a greenish color. [Greenish color and developed.]

Potato.—Moderately luxuriant, filiform, flat, smooth, brown. [Spreading flesh color.]

Grows at both 20° and 37°. Facultative anaerobic.

The Storrs type should, perhaps, be called variety A. The culture from New York did not produce greenish milk.

Ps. lactis aurea n. s. *A yellow, liquefying monotrich.* Found only once, in New York city milk.

Morphology.—Size, 1.4μ x 1μ. No spores, no capsules, no chains. Gram stain positive.

Gelatine colony.—A slow liquefier, with a dark-ringed colony; round. On *litmus gelatine* it is lobed at the edge and not acid.

Gelatine stab.—A filiform needle growth, with a flat surface. Liquefaction begins in one day; stratiform.

Agar streak.—Luxuriant, filiform, raised, papillate, of a lemon-yellow color.

Fermentation tubes.—No acidity, gas, nor closed arm growth in any sugar bouillon.

Bouillon.—A sediment, slight turbidity, and ring-formed pellicle.

Milk.—Rendered alkaline, but no other change noticed.

Potato.—A luxuriant growth, spreading or beaded, contoured; of a lemon-yellow color, moist.

Grows better at 20° than at 37°. Aerobic.

Ps. lactis aerogenes A. n. s. *A gas-producing, liquefying monotrich.* This was found in milk which had been kept at 1° for several weeks. Possibly this is *Ps. coadunta* of Wright.

Morphology.—Size, 1μ–1.2μ x .7μ–.9μ. A short rod, with no chains. No spores, no capsules, and Gram stain negative.

Gelatine colony.—Round, raised or flat, smooth, homogeneous, with wavy edge. Cream-white to brownish color. On *litmus gelatine* the colony is large, moist and acid, like a typical *B. aerogenes.*

Gelatine stab.—A very slow liquefaction. There is a beaded needle growth, a moderately thick surface, rather rough, and, after a long time, a liquefaction.

Agar streak.—Thin, whitish, extending over the whole surface of the agar; not characteristic.

Fermentation tubes.—Acid, gas, and closed arm growth in all sugar bouillons.

Bouillon.—A sediment, slight turbidity and a membranous pellicle.

Milk.—Rendered acid and promptly curdled. A very slight digestion, with a strong odor. The digestion not always apparent.

Potato.—Usually scanty, thin and of a porcelain-white color.

Grows better at 20° than at 37°. Facultative anaerobic.

Ps. fluorescens Gorini. *A fluorescent monotrich.* This organism, received from Gorini, had the following characters when studied by us. A similar organism from Colchester milk differed in points shown in brackets.

Morphology.—Size, 1.2μ–1.8μ x .7μ. No chains, no spores, no capsules. Gram stain negative.

Gelatine colony.—A moderately transparent, liquefying colony, granular and cloudy. It liquefies the whole plate in time. *Litmus gelatine* not acid.

Gelatine stab.—It begins to liquefy in one day, infundibuliform, with a tenacious scum. [Stratiform.]

Agar streak.—Luxuriant spreading, raised, smooth, opaque, gray. [Thin and flat.] The agar shows a green fluorescence.

Fermentation tubes.—Dextrose bouillon is acid, but the others are not. No gas in closed arm growth in any case.

Bouillon.—A sediment and a decided turbidity, but no pellicle. [Pellicle is formed.]

Milk.—Becomes alkaline at 20°, is curdled and completely digested, but not at 37°. Shows a green color and strong odor. [Curdles and digests at 37°, without the green color.]

Potato.—A luxuriant, spreading, thin, white growth. Potato discolored. [Thick.]

Grows better at 20° than at 37°. Facultative anaerobic.

Ps. lactis varians n. s. *An acid-producing, white monotrich.* This organism, incompletely described in 1899, is now more completely described from recently isolated cultures that are probably the same. They are quite common and have been found in abundance in milk that had been preserved for several weeks at 1°.

Morphology.—A rod, forming chains; the individual elements 1μ–1.4μ x .8μ. No spores, no capsules. Gram stain negative.

Gelatine colony.—A round, flat or umbilicate, smooth, rugose colony, of a slight brown, yellow or cream-brown color, producing a slow liquefaction.

Gelatine stab.—Stratiform or infundibuliform. The liquefaction is slow, and one culture produced a dry pit without liquefaction.

Agar Streak.—Filiform, raised, smooth, opaque, white and moderately luxuriant.

Fermentation tubes.—Usually acid in dextrose but not in other sugar bouillons. No gas nor closed arm growth in any bouillon.

Bouillon.—A sediment, an abundant turbidity, and a membranous pellicle.

Milk.—Rendered slightly acid and curdled at 20°, but not at 37°. No visible digestion, but a prominent odor.

Potato.—Somewhat variable. It may be thin, spreading, smooth and gray-brown, or more luxuriant, varying from white to brown.

Grows better at 20° than at 37°, though there is a slight growth at 37°. Aerobic.

Variety A.—One culture of this organism differs from the above description in the following points: Size, 1μ x .5μ. Liquefies rapidly, beginning in one day. The colony forms a granular liquefying pit. Saccharose bouillon acid and shows growth in closed arm. Milk rendered alkaline, curdled, and digested. A luxuriant, thick growth on potato.

Here belong, probably, Gorini's *B. acidificans presamigenes casei* and Grüber's *Ps. fragagariae II.* (Cent. f. Bact. II., XIV., 122), neither of which is thoroughly described. Grüber's organism is not sufficiently described for identification. Gorini's has the following characters:

B. acidificans presamegemus casei Gorini. (Rev. gen. d'lait, III., 505.)

Morphology.—Size, 8μ–10μ x 2μ (?) Produces spores and stains by the Gram method. Though not distinctly stated, this is probably monotrichic.

Gelatine colony.—A round, white, filamentous, irregular colony, which liquefies gelatine.

Agar streak.—A luxuriant, white growth.

Fermentation tubes.—Dextrose bouillon is rendered acid and shows closed arm growth.

Bouillon.—A sediment, turbidity, and pellicle are produced.

Milk.—Rendered acid, curdled, and digested at 20°, without change in color.

Potato.—Grows well.

Grows at 20° and 37°.

Ps. lactis granula n. s. *A non-curdling, liquefying monotrich.* Found in New York city milk and also sent by Harding.

Morphology.—Size, .7μ x 2μ. A rod, forming chains. There are no capsules, and the Gram stain is negative. Spores are produced.

Gelatine colony.—A rapidly liquefying pit is formed, which is uniformly coarsely granular, and has a ciliated margin.

Gelatine stab.—A spiny needle growth and a napiform pit, which later is stratiform. Liquefaction begins in one day.

Agar Streak.—A filiform, raised, smooth, grayish, moderately luxuriant growth.

Fermentation tubes.—Acidity is produced in all three bouillons, but no gas nor closed arm growth.

Bouillon.—A sediment, an abundant turbidity, and a membranous pellicle.

Milk.—Rendered slightly alkaline, but no other change seen.

Potato.—Shows no growth.

Grows hardly at all at 20°, but abundantly at 37°. Aerobic.

THE GENUS BACILLUS, LOPOTRICHIC.

B. syncyanus (Ehrb.) Migula=*cyanogenes* Flügge. *Bacillus of blue milk.* We have not found this species, but a culture was sent to us by Duckwall. Its characters, as determined by us, are as follows:

Morphology.—Size, 1.2μ–2μ x .5μ. Short chains; spores produced, but no capsules. Gram stain irregular. It possesses a tuft of flagella at one end.

Gelatine colony.—A round, raised, smooth, entire colony, of a grayish color, .5 mm. in diameter, in three days.

Gelatine stab.—A filiform, needle growth, and thin surface, which does not spread. After a few days the gelatine turns a dark color at the surface, but does not liquefy.

Agar streak.—Luxuriant, spreading, thin, smooth growth, translucent, white, and showing a dark, smoky fluorescence.

Fermentation tubes.—Dextrose and saccharose, rendered alkaline, without gas or closed arm growth, and no change in color. Lactose becomes very slightly acid, without gas or closed arm growth, and turns a deep blue-black.

Bouillon.—A black sediment, and dark-colored turbidity, with a membranous pellicle.

Milk.—Rendered slightly alkaline without curdling, but develops an odor, and after a few days becomes distinctly blue.

Potato.—A very luxuriant, spreading, thick growth, translucent or opaque, brownish in color.

Grows at both 20° and 37°. Aerobic.

B. lactis olivaceus n. s. *A greenish Peretrich.* This organism has been found in milk directly from the udder.

Morphology.—Size, 1.5μ–2μ x .4μ. A small rod. No chains, no spores, no capsules. Gram stain negative. It has a tuft of flagella at one end.

Gelatine colony.—A round, convex, smooth, homogeneous, entire colony, of a reddish color below the surface. The surface colony has an irregular outline, and a reddish or a greenish color.

Gelatine stab.—No liquefaction, but a needle and surface growth.

Agar streak.—Luxuriant, filiform, raised, smooth, greenish in color.

Fermentation tubes.—No acidity, gas, nor closed arm growth in any sugar bouillon.

Bouillon.—A sediment, an abundant turbidity, and a granular pellicle formed.

Milk.—Rendered alkaline, becomes greenish, and develops a strong odor without curdling.

Potato.—A luxuriant, filiform, flat, smooth growth, brownish-yellow.

Grows both at 20° and 37°. Aerobic.

B. lactis minutus n. s. *A yellow Lophotrich.* This organism was isolated from milk directly from the udder.

Morphology.—Size, .5μ x .4μ. An extremely minute rod, which forms short chains. It produces no spores, no capsules, and does not accept the Gram stain. Several flagella at one end.

Gelatine colony.—A round, convex, smooth, homogeneous colony, of a red color. On *litmus gelatine* it is not acid.

Gelatine stab.—A needle growth, but no surface growth.

Agar streak.—Filiform, raised, smooth, translucent, yellow, moist, luxuriant.

Fermentation tubes.—No acidity, nor closed arm growth in any sugar bouillon.

Bouillon.—A sediment and turbidity, but no pellicle.

Milk.—No action.

Potato.—Very scanty growth, yellowish.

Grows at both 20° and 37°. Aerobic.

B. lactis molocularis n. s. *A white, non-liquefying Lophotrich.* Found in New York city milk.

Morphology.—Size, 1.4μ x .7μ. A lophotrichic rod with flagella at both ends. No spores, no capsules. Gram stain negative.

Gelatine colony.—An opaque bead, smooth, entire, white. On *litmus gelatine* an extremely diffused growth, made up of microscopic dots, appearing to the naked eye simply as a cloud extending over the plate. The individual colonies are visible only under the microscope.

Gelatine stab.—A filiform needle growth and a flat surface, without liquefaction.

Agar streak.—A filiform, flat, smooth growth, of a gray-white color, rather scanty.

Fermentation tubes.—Dextrose is rendered acid, but there is no acidity on other sugar bouillons, and there is never any gas or closed arm growth.

Bouillon.—A sediment, turbidity and a pellicle.

Milk.—Rendered alkaline, and is curdled at 37°. There is no digestion, but an unpleasant odor.

Potato.—A scanty, flat growth, moist, smooth, of a brownish color.

Grows better at 20° than at 37°. Aerobic.

B. lactis Isignii n. s. *A brown, fluorescent Lophotrich.* Found in Isigny cheese, comprising 18% of the bacteria in the centre of the cheese.

Morphology.—Size, .6μ x .9μ. A rod, occasionally forming chains. Spores are developed, capsules are present, and Gram stain is positive. Usually one flagellum is present, though sometimes a tuft is seen at one end.

Gelatine colony.—An extremely rapid liquefier, without any distinct characteristic.

Gelatine stab.—Begins to liquefy in two days, and is complete in twelve days. Sacchate or stratiform.

Agar streak.—Spreading, thin, smooth, luxuriant, translucent white. At 37° the agar becomes brownish, and at 20° it becomes at first flesh color and, later, brown.

Fermentation tubes.—Acidity, gas and closed arm growth in all sugar bouillons.

Bouillon.—A sediment and decided turbidity, but no pellicle.

Milk.—Rendered acid and curdled at both 20° and 37°, but no subsequent digestion noticeable.

Potato.—A luxuriant, thick, smooth growth, of a yellowish color, and a discolored potato.

Grows at both 20° and 37°. Aerobic.

II. Liquefying Lophotrichic Bacilli.

B. lactis fluorescens I. n. s. *A lophotrich producing a smoky fluorescence and a green color.*

Morphology.—Size, 8μ–1.6μ x .4μ–.6μ. A lophotrichic rod with two or three polar flagella. No chains. Spores developed in the ends of the rods. Gram stain negative, and no capsules.

Gelatine colony.—A round, gray, smooth, white colony, which liquefies into a uniformly granular pit.

Gelatine stab.—Liquefies rapidly, infundibuliform, with a cloudy liquid, full of flakes.

Agar streak.—Luxuriant, filiform, smooth, raised, gray, moist. The agar is smoky.

Fermentation tubes.—Dextrose bouillon is rendered acid, but there is no gas nor closed arm growth, nor is there acidity in any other sugar bouillon. In all cases the liquid is turned green.

Bouillon.—A granular sediment and turbidity, but no pellicle. The bouillon is green after a few days.

Milk.—No change in the reaction, but the milk is curdled and digested at both 20° and 37°, and becomes green in color, with a strong odor.

Potato.—Scanty, filiform, flat, smooth, brownish-yellow.

Grows at both 20° and 37°. Aerobic.

B. lactis fluorescens II. n. s. *A green fluorescent lophotrich.* This is a common form. The culture from which the following description was made was isolated from Camembert cheese. Some variations are shown in the points in brackets.

Morphology.—A lophotrichic rod, sometimes forming chains. Individual elements, 1μ–1.4μ x .6μ–.9μ. No spores nor capsules. Gram stain negative.

Gelatine colony.—A very rapid liquefier, forming a cloudy pit. [A bead and a granular pit.] On *litmus gelatine* it is strongly alkaline.

Gelatine stab.—Begins to liquefy in about three days, napiform. [Infundibuliform.] The liquid shows fluorescent green, and there is a surface membrane.

Agar streak.—Luxuriant, filiform or spreading, raised, smooth, of a white or brownish color. The agar turns green. The depth of the green color varies in different cultures. [Growth on agar in one culture is green, as well as the agar itself.]

Fermentation tubes.—Dextrose bouillon is acid, but no other sugar bouillon, and there is no gas, nor closed arm growth. [Dextrose not acid.]

Bouillon.—A sediment, a decided turbidity, and a flocculent pellicle. The liquid is green.

Milk.—Is alkaline and curdled at 20° and subsequently digested, green. Has a pleasant odor.

Potato.—Scanty, flat, smooth, brownish. [Luxuriant.]

Grows at both 20° and 37°, but better at 20°. Aerobic, or facultative anaerobic.

B. fluorescens minutissimus. A fluorescent lophotrich. This organism, described in 1899, is probably identical with the last. It shows slight variations and its description is reinserted here.

Morphology.—An extremely small rod. Size, .5μ–.7μ x .5μ. No chains, no spores, no capsules. Flagella were not made out.

Gelatine colony.—A smooth, liquefying pit, without a nucleus, but granular.

Gelatine stab.—Liquefies stratiform, with a cloudy liquid, which is not green.

Agar streak.—Luxuriant, soft white growth, with a green fluorescence.

Bouillon.—A sediment and turbidity are formed, with a pellicle. In two days the bouillon is very cloudy, but not green.

Milk.—The milk is curdled with a slight green color at the top, but there is no apparent digestion.

Potato.—A luxuriant, white to brownish growth, with no discoloration.

Grows at both 20° and 37°, but the green color does not appear at 37°. Aerobic.

B. lactis fluorescens III. n. s. *A green, non-fluorescent lophotrich.* This organism does not produce a fluorescence, but the fact that it turns milk green suggests the relationship to the last organisms, and hence we class it here.

Morphology.—A slender rod.* Size, 1.5μ–3μ x .4μ–.7μ. No chains, no spores, no capsules. Gram stain negative.

Gelatine colony.—A very rapidly liquefying colony, uniformly granular, but not characteristic.

Gelatine stab.—Begins to liquefy in two days, stratiform.

Agar streak.—Luxuriant, spreading, flat, smooth growth, gray-brown, moist.

Fermentation tubes.—Acidity and closed arm growth in dextrose and sometimes lactose, but not in saccharose. No gas produced. The liquid is usually, though not always, green.

Bouillon.—A sediment, slight turbidity, and a membranous pellicle.

Milk.—Becomes alkaline, curdles, and digests. The digested liquid is green or yellow in color, and has a strong odor.

Potato.—Growth scanty, but the potato is discolored.

Grows at both 20° and 37°. Facultative, anaerobic.

B. lactis moruloideus n. s.

Morphology.—Size, 1μ–1.5μ x 1.2μ. No chains, spores, or capsules. Gram stain irregular, frequently showing only a single flagellum.

Gelatine colony.—A slowly liquefying pit, which is lobed and moruloid, with a putrefactive odor. In *litmus gelatine* it is not acid.

Gelatine stab.—A needle growth, and a stratiform liquefaction, beginning in one day, and never complete.

Agar streak.—Filiform, raised, smooth, rather opaque, white, moist, not luxuriant.

Fermentation tubes.—Dextrose is acid but no other sugar bouillon. Occasionally growth in closed arm, but no gas.

Bouillon.—A sediment, turbidity, and a pellicle.

Milk.—Is rendered acid and curdled with a subsequent digestion, with a strong odor and a yellowish color.

Potato.—Scanty, thin, smooth, white, moist; no discoloration.

Grows at 20°; very slightly at 37°. Facultative anaerobic.

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* Frequently appearing monotrichic, from the breaking away of some of the flagella.

THE GENUS BACILLUS, PERITRICHIC, NON-LIQUEFYING.

I. No acid in dextrose or other sugars.

B. lactis nigroferous n. s. *A black bacillus.* This bacillus was obtained from milk in New York city, and is distinctly characterized by its *blue-black, nearly jet-black color. B. niger* of Biel, and a species isolated by Gorini, produces black colonies on gelatine, but not on agar. We have seen only one culture of this remarkable bacillus, which is, so far as we know, the only bacterium described of a jet-black color.

Morphology.—A peritrichic rod. Size, .9μ–1μ x .9μ. There are no spores, and the organism does not accept the Gram stain. No chains are formed.

Gelatine colony.—A round, thin, smooth, moist colony, at first white in color, but later a very deep blue-black. On *litmus gelatine*, black; in a pit, not acid.

Gelatine stab.—A needle growth and a good surface growth, slightly arborescent at the top, becoming black.

Agar streak.—A moderately thick, smooth, moist growth, which becomes jet-black.

Fermentation tubes.—There is growth in the closed arm in all three sugar bouillons, but no acid is produced, and no gas. An indigo blue scum appears.

Bouillon.—An abundant sediment, a turbidity, and a blue-black pellicle.

Milk.—No change, except the formation of a thick, black scum. Later the milk becomes black.

Potato.—A thick, spreading, moist, very luxuriant growth, of a deep blue-black color; potato discolored.

Grows at 37° and 20°, but not well at 37°. Aerobic.

We have several times isolated from milk bacilli that seem essentially identical with *B. Zenkeri* (Hauser). They have been found in milk from several localities in Connecticut. This essential agreement is indicated by the name we have given it. The culture as studied by us has the following characters:

B. lactis Zenkeri n. s. (Hauser). *A rhizoid or proteus-like bacillus.*

Morphology.—Size, 2μ–3μ x 1μ. Frequently in chains. It produces no spores, and does not accept the Gram stain.

Gelatine colony.—*A peculiar rhizoid colony* is formed, with lateral extensions of variable character.

Gelatine stab.—A prominent needle growth and a lobate or polypiform surface.

Agar streak.—A thick, luxuriant, white growth, with radiating fibres from a ragged edge. Its surface is dull. Sometimes viscous.

Fermentation tubes.—No acidity, gas, nor growth in closed arm in any sugar bouillon.

Bouillon.—A sediment, but no pellicle, and usually no turbidity.

Milk.—Unchanged, except for a slight alkalinity. Some specimens, however, show a slight sliminess.

Potato.—A moderately thick, dirty white or brown growth, which is apt to be rough and dry. Sometimes it is yellow, and the potato is discolored.

Grows both at 20° and at 37°, but better at 37°. Aerobic.

One culture of this organism which we have found, spread over the surface of a gelatine stab as a thick felt, but on potato it produced no growth. The characteristic rhizoid colony, however, leads us to place it here.

B. lactis Colchesterii n. s. *A yellow, rhizoid, peritrichic bacillus.*

Morphology.—Size, 1μ–.2μ x .7μ–.9μ, forming short chains. It accepts the Gram stain, and has an evident capsule, but produces no spores.

Gelatine colony.—A rhizoid colony is produced that looks *exactly like a mold.*

Gelatine stab.—There is a needle growth and a surface growth.

Agar streak.—Mold-like colonies are formed which extend under the surface of the agar. The growth is luxuriant and of a yellow color. Frequently with an iridescence.

Fermentation tubes.—No acidity, gas, nor growth in closed arm in any sugar bouillon.

Bouillon.—An abundant sediment, a slight turbidity, but no pellicle.

Milk.—No action on milk.

Potato.—A thin, yellow growth, not widely spreading.

Grows at both 20° and 37°. Aerobic.

Only a single culture of this organism has been found in milk, from Colchester, Conn. It is readily distinguished from other bacilli by its mold-like colony, and its yellow color.

B. lactis nebulus n. s. *A smoky bacillus.*

Morphology.—A very small rod. Size, .8μ x .3μ. It forms chains, is actively motile, produces no spores, and does not accept Gram stain.

Gelatine colony.—A thick, contoured, smooth colony of a yellow color. On *litmus gelatine* a plain white colony is formed, not characteristic.

Gelatine stab.—An abundant needle growth and a transparent surface growth.

Agar streak.—A luxuriant, rather thick, smooth growth, opaque, white. The agar shows a *smoky fluorescence.*

Fermentation tubes.—Neither acidity, gas, nor growth in closed arm in any sugar bouillon.

Bouillon.—An abundant, amorphous sediment, and a slight turbidity, with a pellicle on the surface.

Milk.—No action.

Potato.—A thin, scanty, white growth.

Grows better at 20° than at 37°. Aerobic.

Two cultures have been found which we have carefully studied and regarded as probably the same. One of them was isolated in 1895 and the other in 1903. The former did not produce the smoky fluorescence in agar, nor did it produce a pellicle on bouillon. In other respects they were the same.

II. Acid in Dextrose or other Sugars.

B. lactis citreus n. s. *A yellow, non-liquefying peritrich.*

Morphology.—Our observations were incomplete when the culture was lost. It is a peritrichic (?) rod, .8μ x .5μ, which forms no chains or spores.

Gelatine colony.—A white, opaque colony, that later becomes yellow, 2 mm. in diameter.

Gelatine stab.—A needle growth and a lemon-yellow surface growth; umbilicate.

Agar streak.—A luxuriant, lemon-yellow growth, smooth, moist.

Fermentation tubes.—Probably acid without gas.

Bouillon.—A sediment, a turbidity, and a pellicle, the latter sinking to the bottom.

Milk.—Becomes acid and curdles into a hard curd, with a layer of liquid on top.

Potato.—A luxuriant growth which is at first white and then lemon-yellow.

Grows at 20° and 37°. Aerobic.

B. lacto rubifaciens. Gruber. *A red pigment bacillus.* This culture was sent us from Kiel by Weigmann. The culture when received and studied in our laboratory, produced no color except a slight pinkish tint in milk.

Morphology.—An active rod, 2μ–3μ x .7μ. No chains are formed; it does not accept Gram stain. Spores are formed, but no capsule.

Gelatine colony.—Thick, contoured, gyrose, white. On *litmus gelatine* it becomes 5 mm. in diameter, is acid and lobed, with gyrose and with a mottled surface.

Gelatine stab.—A good needle growth, villous, with a spreading surface.

Agar streak.—Linear, moderately thick, white.

Fermentation tubes.—All three sugars develop acidity, and show growth in the closed arm, but no gas is produced.

Bouillon.—A flocculent sediment, a turbidity, and a ring-formed pellicle.

Milk.—Rendered acid and curdled into a gelatinous mass at 20°, but not at 37°. When heated the jelly becomes a hard curd, with a jelly-like whey. The milk has an odor of the barn, and a pinkish color.

Potato.—Rather thick, white, luxuriant. Potato discolored.

Grows at both 20° and 37°, though better at 20°. Facultative anaerobic.

B. lactis sulcatus n. s. *A non-gas-producing, acid bacillus, without spores.* This organism has been found twice at intervals of three years. In one case it came from market milk, and in the other directly from the udder. There were slight differences in the colonies of the two cultures, and one culture failed to curdle milk even when heated. They seem to agree fairly well with a culture from cream described by Severin (Cent. f. bact. II., XI., 1903, p. 202). We name it from its resemblance to *B. sulcatus.*

Morphology.—An active rod. Size, 2μ–2.5μ x .6μ. No chains nor spores. It accepts the Gram stain.

Gelatine colony.—A large [6-8 mm.], spreading, white colony, with a rough, irregular, contoured surface, outline indented. On *litmus gelatine* the colony is acid.

Gelatine stab.—A needle growth and a very thin surface growth.

Agar streak.—Thin, linear, white, rather scanty, and not characteristic.

Fermentation tubes.—All three sugar bouillons show acidity and growth in the closed arm, but no gas.

Bouillon.—A flocculent sediment, but no turbidity nor surface pellicle.

Milk.—Becomes acid but does not curdle unless heated. No other change.

Potato.—Thin, scanty, moist, white.

Grows both at 20° and 37°. Facultative anaerobic.

B. aromaticus lactis Grimm, (Cent. f. Bac. u. Par. II., VIII., 584, 1902) seems to belong here.

For peritrichic gas-producing acid bacilli see p. 182.

B. disenteriae Shiga. This organism, regarded as the cause of some forms of dysentery and some cases of summer complaint, we insert here, although, so far as we know, it has not actually been found in milk. It is strongly suspected, however, that it is sometimes distributed by milk, and we have thought it well to include it in our list. The characters as given below are described by Vedder and Duval.

Morphology.—A peritrichic rod, 1μ–3μ in length, and very slender. Sometimes it is extremely short, almost a coccus. It produces no chains nor spores. It does not accept the Gram stain.

Gelatine colony.—Practically identical with the colony of *B. coli communis*. A thin, slightly spreading, white colony, which is acid in litmus agar.

Gelatine stab.—There is a needle growth and a slight surface growth which does not spread.

Agar streak.—A luxuriant, uneven, rather thick, cream-white growth, which later shows a feathery edge.

Fermentation tubes.—All sugar bouillons are rendered acid but no gas is produced.

Bouillon.—A sediment and turbidity are formed, and occasionally a thin pellicle; later the liquid is clear.

Milk.—At first acid, but later alkaline. No curdling nor other change.

Potato.—A luxuriant, rough, thick, spreading, yellowish growth.

Grows better at 37° than at 20°. Produces indol, and is pathogenic.

This is very similar to *B. coli*, but grows less rapidly at 37°. They are not easy to separate from each other, special culture methods being necessary.

B. lactis fragariae (Weig.). This culture was sent me by Weigmann, labeled *Pseudomonas fragariae*. The culture we have received is a peritrichic bacillus rather than a Pseudomonas, and does not produce any peculiar odor in

milk. Whether this is due to a contamination and thus to a loss of the original culture, or whether it has changed its characters, there was no way of determining. The culture which we received shows the following characters:

Morphology.—A bacillus 1.3μ–1.5μ x .7μ–.9μ. It forms no chains nor spores, and does not accept the Gram stain.

Gelatine colony.—A round, thick, smooth, homogeneous, entire colony of a white color. On *litmus gelatine* it is nearly transparent, mottled, .5 mm. in diameter, and gives an odor of ammonia.

Gelatine stab.—A needle growth, and thin surface growth.

Agar streak.—A scanty, thin, smooth, moist, white, growth.

Fermentation tubes.—Acidity is produced in dextrose, but no gas and no closed arm growth. No effect upon other sugar bouillons.

Bouillon.—A flocculent sediment, decided turbidity, and a pellicle.

Milk.—Is rendered alkaline and slightly transparent, but no other change. A slight odor is produced.

Potato.—A scanty, thin, smooth, moist, white growth.

Grows at 20° and at 37°. Aerobic.

THE GENUS BACILLUS, PERITRICHIC, LIQUEFYING.

I. Producing Pigment.

B. prodigiosus (Ehrb) Flügge. This well-known organism we have found many times in milk. So far as we have seen, it never produces any trouble in the dairy. Its characters are well known, but we insert them here for completeness' sake.

Morphology.—Size, 5μ–1μ x .5μ, with chains and coccoid forms. No spores.

Gelatine colony.—Round, oval, entire, reddish-brown, with translucent borders. Surface irregular and liquefying with production of a red pigment.

Gelatine stab.—Saccate liquefaction, with reddish sediment.

Agar streak.—White, becoming red.

Fermentation tubes.—Glucose is not acid, gas production variable.

Bouillon.—Turbid, a reddish sediment, and a pellicle.

Milk.—Acid coagulated and subsequently digested, with more or less of a pink color.

Potato.—Rose-red, moist, becoming dark-red to purple.

Grows best at 20°–25°. Aerobic.

B. butyri rubri, Stadling and Poda: (Milch. Zent. II., p. 97, 1906,) *A red, liquefying bacillus.* This bacillus, recently isolated from red butter by Poda, has been carefully studied by him and is quite similar to *B. prodigiosus.* It differs, however, very decidedly in its gelatine colony and in its power of producing red pigment, which is much less than in *B. prodigiosus.* It produces red spots in butter. Poda has given it the above name and regarded it as a distinct type with the following characters:

Morphology.—A peritrichic rod. Size, 1μ–1.5μ x .7μ–.8μ. It forms chains but no spores nor capsules, and does not accept Gram stain.

Gelatine colony.—Round to oval, brown or yellow colonies, with a central colony in a liquid pit. The colony is opaque and granular, 4 mm. in diameter in 48 hours, and liquefies at the edge; with a cheesy smell.

Gelatine stab.—A needle growth and a shallow liquefying pit, with no color. It then becomes infundibuliform, but no red pigment develops.

Agar streak.—A luxuriant, opaque growth, with a central wine-red streak, and a colorless peripheral zone. Condensation water, dark colored.

Fermentation tubes.—Not given, but probably produces acid and gas.

Bouillon.—A sediment and turbidity. There is no pellicle, but there is a rose-red color near the surface.

Milk.—Made acid, and curdled with a cheesy smell and a rose-red color. It is subsequently digested into a yellow liquid with a cheesy smell.

Potato.—A luxuriant, carmine red growth, the pigment appearing at 37° as well as at 20°.

Grows at 20° and 37°, but the color is not so well developed at the higher temperature.

B. lactis citronus n. s. *A lemon-yellow, peritrichic bacillus.* This we have found but once, in milk fresh from the udder.

Morphology.—Peritrichic bacillus. Size, 1.5μ x .8μ. It forms no spores, accepts the Gram stain and has evident capsules. No chains are formed.

Gelatine colony.—A round, convex, smooth, homogeneous, entire, white colony, which at liquefaction shows radiation.

Gelatine stab.—Liquefies, infundibuliform.

Agar streak.—Filiform, flat, smooth colony, lemon-yellow color, luxuriant.

Fermentation tubes.—Lactose is rendered acid, but the other sugars are not acid. Growth in the closed arm shows in all cases, and no gas is produced.

Bouillon.—A sediment and an abundant turbidity, but no pellicle.

Milk.—Becomes acid and is curdled at both 20° and 37°. The milk is subsequently digested with an odor, but no color.

Potato.—Spreads over the potato, thin, lemon-yellow, luxuriant.

Grows both at 20° and 37°. Facultative anaerobic.

B. lactis Harrisonii n. s. *A slimy milk, yellow bacillus.* Isolated by Harrison and described by him. (Rev. gen. d'Lait, 1906). I have ventured to name it after him.

Morphology.—Somewhat irregular. Size, .25μ–.75μ x .3μ–3μ. No chains nor spores, and no capsules. It stains by the Gram method.

Gelatine colony.—Irregular, lobulate, slimy, becoming umbonate. Sinks in a pit 3–7 mm. in diameter, from which the whole colony can be removed by a needle.

Gelatine stab.—Outgrowths from the needle track. In two weeks it sinks into a pit 4 mm. deep, and there is no further change.

Agar streak.—Luxuriant, viscous and dull, at first shiny, later dry; citron yellow; spreading.

Fermentation tubes.—Not described, but apparently no acid and no gas.

Bouillon.—A turbidity, sediment, and a ring pellicle.

Milk.—Rendered alkaline, but neither curdled nor digested. It is turned yellow and becomes slimy.

Potato.—A luxuriant growth, spreading and intensely yellow.

Grows at 20° and at 37°. Aerobic.

B. lactis fluorescens IV. n. s. *A fluorescent, liquefying bacillus.*

Morphology.—Size, 2.5μ–3.3μ x .9μ–1.5μ. Forming chains. It produces central spores, accepts the Gram stain, and shows an evident capsule.

Gelatine colony.—A granular colony with a central nucleus, liquefying almost immediately.

Gelatine stab.—Liquefying rapidly, infundibuliform.

Agar streak.—Filiform, flat, contoured, opaque, yellowish, moist, and later, wrinkled. The agar shows a yellow-green fluorescence.

Fermentation tubes.—All three tubes show growth in closed arm; dextrose alone being acid. No gas produced.

Bouillon.—A flocculent sediment, turbidity, and pellicle. The liquid is yellow at the top.

Milk.—Rendered alkaline, is curdled at 37°, and is subsequently completely digested, both at 20° and 37°. It becomes yellow to orange in color.

Potato.—Spreads completely over the potato, rather thin and yellow, luxuriant.

Grows both at 20° and at 37°. Is facultative aerobic.

Variety A.—Found in milk in Colchester. Differs from the last in the following points. Size, 1.5μ x .6μ. Gram stain is negative. The flagella are extremely long and numerous, and protrude from very thick capsules. Gelatine stab shows a greenish growth, which later becomes yellow. Yellow pigment is not produced on agar or on potato. There are no wrinkles on agar and no growth in the closed arm of fermentation tubes.

The differences between these two varieties are considerable, and are perhaps sufficient to require recognition under separate names. At present, however, we leave them together.

B. lactis niger (Gorini) n. s. *A black liquefying bacillus.* This organism, which was sent us from Geneva by Harding, is almost identical with *Ps. lactis niger* of Gorini. See p. 154. The latter, however, is monotrichic, while this is peritrichic. The other differences are very slight.

Morphology.—Size, 2μ–3.5μ x .9μ. Long chains are produced. The organism stains with the Gram method, produces no spores and shows no capsules.

Gelatine colony.—Not characteristic. A slow liquefier, forming a pit which is at first clear and then cloudy. No acid is produced upon litmus gelatine.

Gelatine stab.—Begins to liquefy on the first day, infundibuliform. In ten days the gelatine is about ¾ liquefied.

Agar streak.—Spreading, thin, smooth, opaque, white, moist, and later wrinkled. Quite luxuriant.

Fermentation tubes.—There is a very slight acidity in all three sugars. No gas and no closed arm growth.

Bouillon.—After three days there is a sediment, a turbidity, and a membranous pellicle.

Milk.—Is rendered alkaline, curdled, and subsequently digested both at 20° and at 37°.

Potato.—Spreading, flat, irregular surface or wrinkled, and becoming blue-black.

Grows better at 37°, very little at 20°. Aerobic.

B. lactis arborescens II. An arborescent spore-producing bacillus. This organism was found originally in 1899 and a second culture was isolated from dust in 1904. The original culture was kept in the laboratory for four years and then tested again. It was found to agree with the original description except that it no longer produced the arborescent growth in gelatine.

Morphology.—Size, 1.5μ–4μ x .8μ. No chains nor capsules; spores, sometimes in the ends of the rods and sometimes in the center; Gram stain positive.

Gelatine colony.—Filamentous, 1 cm. in diameter, of radiating knotted fibers and sometimes showing secondary radiations from the knots; slowly liquefying. In *litmus gelatine* deep dry pits with radiating filaments.

Gelatine stab.—A dry pit, which later liquefies. Needle growth arborescent.

Agar streak.—Very thin, scarcely visible, covering the whole surface, white.

Fermentation tubes.—No acidity, gas, or closed arm growth in any sugar bouillon.

Bouillon.—A flocculent sediment, a slight turbidity and a tough scum.

Milk.—No action.

Potato.—Thin, not luxuriant, diffuse gray or brown.

Grows at 20° and 37°. Aerobic.

B. lactis rhizoides n. s. *A rhizoid, non-arborescent bacillus.*

Morphology.—Size, 3μ x .8μ. No chains, no spores, no capsules, Gram stain negative.

Gelatine colony.—A myceloid colony, slowly liquefying. On *litmus gelatine* the colony is proteus like.

Gelatine stab.—A needle growth and a saccate liquefaction, beginning in three or four days.

Agar streak.—Spreading, smooth, thin, transparent, white, luxuriant, moist.

Fermentation tubes.—No acidity, gas, nor closed arm growth in any sugar bouillon.

Bouillon.—A slight sediment and turbidity, but no pellicle.

Milk.—No action.

Potato.—A very scanty white growth, with discolored potato.

Grows at 20° and very slightly at 37°. Facultative anaerobic.

B. lactis mycoides n. s. *Rhizoid, spore-bearing bacilli.* This type of bacillus we have found very frequently. There are some variations in the characters of the various cultures. The one described below, which we take as a type, was from Dr. Maher, and has been used by him in numerous inoculation experiments against certain diseases. The variations which we have found in other cultures are indicated in brackets.

Morphology.—Size, 1μ–4μ x .6μ–1.2μ. Long chains produced, spores present, no capsule, and Gram stain positive.

Gelatine colony.—A small burr like, rhizoid colony, soon liquefying and forming a pit with a nucleus. [The rhizoid character is not always found, and the liquefaction may be slow. The color is sometimes yellowish; it sometimes shows tangled threads like anthrax.]

Gelatine stab.—An arborescent needle and a cratiform liquefaction. [Infundibuliform without arborescence.]

Agar streak.—Luxuriant, dull, wrinkled, white, tough. [Yellowish.]

Fermentation tubes.—No acidity, gas, nor closed arm growth in any sugar bouillon.

Bouillon.—A sediment, turbidity, and a pellicle.

Milk.—Rendered alkaline and curdled after a few days. Digested into an amber colored or yellowish liquid.

Potato.—Luxuriant, velvety, dry, wrinkled, white.

Grows at 20° and 37°. Aerobic or facultative anaerobic. [A ground-glass like appearance, with liquid under the folds. Sometimes of a pasty consistency.]

B. subtilis. Is extremely common in milk, though never in great numbers. While it will grow in sterilized milk, it does not usually thrive in milk containing lactic bacteria. In old milk it is, therefore, usually overgrown by the lactic organisms. We describe a typical culture and two varieties below.

B. subtilis (Ehrb.).

Morphology.—Size, 1.5μ–4μ x .6μ–1.5μ, commonly forming chains. Spores are produced in abundance. The Gram stain is positive, and there is no capsule. The size is somewhat variable in different cultures.

Gelatine colony.—A rapidly liquefying colony, with irregularly distributed granular masses. The appearance of these masses is striking but not uniform, and hence not characteristic.

Gelatine stab.—Begins to liquefy in one day, crateriform and later stratiform.

Argar streak.—A filiform or spreading, raised, contoured, cretacious, white, growth, frequently wrinkled and dull. In some cultures it is quite dry.

Fermentation tubes.—No acidity, gas, nor closed arm growth, in our cultures, although Chester says dextrose is made acid.

Bouillon.—A sediment, turbidity, and pellicle.

Milk.—Rendered alkaline, curdled and digested at both 20° and 37°.

Potato.—A spreading, raised, gray, dry, or moist, luxuriant, wrinkled growth. Some cultures are yellowish and thin.

Grows well at 20° and 37°. Aerobic.

Variety A.—Differs in the following points from the type. Size, 2.5μ x .5μ. Gram stain negative; colony with a radiate pit which is later gyrose; agar streak shows no wrinkling; potato discolored, a bluish-black.

Variety B.—Size, 3.5μ x .9μ. Gram is negative; liquefaction is so slow that it hardly occurs on gelatine plate, the colony being round, smooth, raised, entire, translucent, yellowish; a slow infundibuliform liquefaction; acid is produced in dextrose and saccharose, and a closed arm growth in lactose and saccharose; on potato the growth is yellow.

Here belong several of the forms of *Tythothrix* of Duclaux, *(turgidus, filiformis, urophalum,)* and also *B. Bernensis*, found in Emmenthaller cheese.

At this place should be included *Ty. vergula* of Duclaux, found in cheese, and *B. mesentericus* of Flügge, neither of which is sufficiently described to be clearly identified, as equivalent to any of the organisms which we have already described.

B. lactis Cromwellii n. s. *Producing a slimy jelly on potato.* This has been found but once, but its peculiar potato growth demands special recognition.

Morphology.—Size, 1μ–.6μ. Forming chains. Spores are developed and also a capsule. Flagella not definitely made out but probably peritrichic.

Gelatine colony.—An opaque colony, in a pit, at first somewhat lobate and then breaking into opaque granules as the liquefaction increases.

Gelatine stab.—At first a dry crateriform pit, with later a liquefaction and a scum.

Agar streak.—Luxuriant, opaque, white, with a thin edge; the whole subsequently becoming yellow.

Bouillon.—A sediment, turbidity, and a pellicle, with a tinge of reddish or brown color.

Milk.—Rendered alkaline, curdled, and digested at both 20° and 37°; may digest without curdling. The milk becomes nearly transparent in 12 days. A yellow scum sometimes forms, but soon sinks to the bottom.

Potato.—A moist, slimy, jelly develops all over the potato, extremely profuse. White or yellowish-brown color.

Grows at both 20° and 37°. Aerobic.

B. janthinus (Zopf.), *violaceus* (Macé). *A violet bacillus.* We have never found this, but it is said to occur in milk occasionally. Its description is not complete, as follows:

Morphology.—Size, 2μ–5μ x .4μ–.5μ. It forms chains and spores and stains by the Gram method. Flagella not described.

Gelatine colony.—A rapid liquefier with a membrane on the surface, which assumes a violet tinge in some cases.

Gelatine stab.—A rapid liquefier, forming a cloudy liquid and a pellicle; violet in color.

Agar streak.—A luxuriant growth, at first white and then violet; moist, wrinkled.

Fermentation tubes.—Not given; probably no acid or gas.

Bouillon.—A turbidity and a slight pellicle; the bouillon becomes violet.

Milk.—The reaction is unchanged, or slightly acid. There is no curdling, but there forms a violet surface layer.

Potato.—The original needle track is violet, but a dark brown growth covers the whole surface of the potato. Luxuriant.

III. No pigment and no acid in dextrose or other sugars.

B. lactis circulans I. and II. White circulating bacilli. These two varieties have not been found by us since their original isolation in 1895 as described previously. The two cultures, found at different times, differ from each other in the points indicated in brackets, which refer to No. II. Both of them showed the circulation which is characteristic of this type. Their characters are as follows:

Morphology.—Size, 1.5μ x 6μ. Forming chains.

Gelatine colony.—A protruding bead or in a dry pit; then liquefying and showing a circulation in the liquid.

Gelatine stab.—Liquefaction slow; a narrow funnel is formed with a dry pit above, and a rotating axis in the center of the funnel below. [Rotating axis absent.]

Agar streak.—Luxuriant, thick, yellowish.

Bouillon.—A sediment, turbidity, and pellicle, but the liquid clears up after six weeks.

Milk.—Slightly alkaline or unchanged in reaction. Digests without [with] curdling in 25 days, into a cloudy liquid with a sediment.

Potato.—A rather scanty, thin, watery growth, white. [Reddish brown.] Potato sometimes discolored and sometimes not.

Grows both at 20° and 37°. Aerobic.

B. aerolactis n. s. *A non-acid, gas-producing bacillus.* This has been isolated several times from milk. In one case it was from a sample of old milk that developed a pleasant, fruity flavor. This culture produced in milk, however, a strong odor of decay. There are slight variations in the different cultures which we have isolated, but we regard them as identical. Some of the variations are indicated by brackets.

Morphology.—Size, 1μ–1.2μ x .4μ–.8μ. No chains have been found. Spores are produced, sometimes at the middle and sometimes at the end. There is frequently a capsule and the Gram stain is negative. [Capsule wanting.]

Gelatine colony.—A rapidly liquefying colony, cloudy and sometimes showing a nucleus, but not characteristic.

Gelatine stab.—Begins to liquefy in one day, infundibuliform; complete in 8 to 10 days.

Agar streak.—Luxuriant, capitate, smooth or contoured, gray, moist, commonly viscous.

Fermentation tubes.—Grows in the closed arm; produces gas in dextrose and saccharose and in some cases in lactose. No acidity is developed. [One culture shows gas in saccharose only.]

Bouillon.—A sediment, a strong turbidity, and a ring-formed pellicle.

Milk.—Either unchanged in reaction, or rendered slightly alkaline; is curdled both at 20° and 37°; is always digested more or less completely and always shows the presence of gas bubbles. The odor is variable, in some cases being that of decay and in others that of cheese.

Potato.—Spreading, raised, contoured, gray, moist, luxuriant, with a discolored potato.

Grows at 20° and abundantly at 37°. Facultative anaerobic.

We have isolated this organism from milk from several sources. It is quite similar to *B. megatherium* of Du Bary.

B. lactis tetragenes n. s. *A rhizoid liquefying bacillus.*—The original culture of this organism was sent me by Weigmann and isolated from cheese. The characteristics below were determined by us from Weigmann's culture. Later we found apparently the same organism in milk here. The points where our new culture differed from that of Weigmann are indicated in brackets.

Morphology.—A large rod, not forming chains. Size, 3μ x .7μ [2.5μ x 1.4μ]. No spores, no Gram stain, but a capsule is evident.

Gelatine colony.—A rhizoid or proteus-like colony, of large size, slowly liquefying. It is not acid in *litmus gelatine.*

Gelatine stab.—Begins to liquefy in one day [three days], liquefaction stratiform. At first an arborescent needle track. [Not arborescent.]

Agar streak.—A filiform, flat or raised, smooth, gray growth, moderately luxuriant, moist.

Fermentation tubes.—No action upon any sugar bouillon.

Bouillon.—A slight turbidity and a tenacious pellicle is formed, but no sediment. [Sediment without pellicle.]

Milk.—No change in reaction, or a slight alkalinity. Milk is curdled at the bottom, at 37°, and is subsequently slightly digested, with a faint pinkish color. [Yellowish.]

Potato.—A luxuriant, wide spreading, thin, contoured growth, of a gray color, with a discolored potato. [Growth is slight.]

Grows at 20° and 37°. [Growth at 37° slight.] Aerobic.

B. lactis distortus n. s. This resembles *Ty. distortus* of Duclaux.

Morphology.—Size, 3μ x .7μ. Chains are formed, but no spores or capsules. The Gram stain is positive.

Gelatine colony.—A slowly liquefying colony, with a uniformly granular liquid. On *litmus gelatine* it is not acid.

Gelatine stab.—A slow, stratiform, liquefaction, with a cloudy liquid and a scum.

Agar streak.—Filiform, raised, smooth, translucent, white, moist, not luxuriant.

Fermentation tubes.—No acidity, gas, nor closed arm growth in any sugar bouillon.

Bouillon.—A turbidity and a thick, wrinkled scum, but no sediment.

Milk.—No change in reaction, or amphoteric; the milk is curdled slowly and is later digested.

Potato.—A luxuriant, white, much folded, dry or pasty growth.

Grows at 20° and 37°. Aerobic.

B. lactis gelatinosus n. s. *A bacillus producing jelly-like milk.* One culture of this organism was isolated from milk here and a second was sent from Geneva. Where the latter organism differs from ours the differences are indicated by brackets.

Morphology.—Size, .8μ x .6μ. [1.8μ x .6μ.] No chains, no spores, no capsule, and Gram stain negative.

Gelatine colony.—A round, smooth, white colony, which slowly liquefies [rapid liquefaction], not characteristic.

Gelatine stab.—Slow liquefier, cratiform, white. [Rapid liquefier.]

Agar streak.—A filiform, smooth, raised, brownish or cream-colored growth, luxuriant, moist.

Fermentation tubes.—No acidity, gas, nor closed arm growth in any bouillon. [Slight acid reaction in lactose and some closed arm growth in saccharose.]

Bouillon.—A granular sediment, a turbidity and a membranous pellicle.

Milk.—Rendered acid and curdled, and upon digesting becomes a transparent jelly.

Potato.—A moderate growth, raised, smooth, brownish with a slight odor. [Spreading.]

Grows at both 20° and 37°. Aerobic. [Facultative anaerobic.]

B. lactis tenuis n. s. (Ducl.) Several cultures of *non-acid liquefying bacilli, with no wrinkling*, and no rhizoid colonies have been studied. Here would belong *Ty. tenuis*, and *Ty. Scaber* of Duclaux. We describe two varieties from our cultures to which we have given the above names, derived from Duclaux.

Morphology.—A slender rod. Size, 1.2μ x .5μ. No chains, no spores, no Gram stain.

Gelatine colony.—A rapidly liquefying colony, not characteristic.

Gelatine stab.—An arborescent needle growth and a stratiform, later an infundibuliform, liquefaction, beginning in one day, half liquefied in ten days.

Agar streak.—Luxuriant, umbonate, smooth, gray, moist, iridescent.

Fermentation tubes.—Acid, gas, and closed arm growth in dextrose. Closed arm growth in other bouillons but no acid nor gas.

Bouillon.—A granular sediment, a decided turbidity, and a flocculent pellicle.

Milk.—Rendered alkaline, digested, curdled, and subsequently digested into a gelatinous mass at both 20° and 37°, with an unpleasant odor. Later the odor is of old cheese.

Potato.—A filiform, capitate, smooth, gray growth, not very luxuriant, with potato discolored.

Grows abundantly at 20° and 37°. Aerobic. Found in Camembert cheese.

Variety A.:

Morphology.—Size, 2μ–3μ x .5μ–.7μ. No chains, no spores, a very evident capsule and Gram stain positive.

Gelatine colony.—A very slow liquefier, not characteristic.

Gelatine stab.—An arborescent needle growth, with crateriform liquefaction, beginning in one day.

Agar streak.—Filiform, flat, contoured, transparent, gray, luxuriant, moist.

Fermentation tubes.—No gas, acidity, nor closed arm growth in any bouillon. Saccharose is rendered acid. No other effect in any sugar bouillon.

Bouillon.—A slight sediment is produced, but no other effect.

Milk.—No action on milk.

Potato.—Spreading, thin, smooth, translucent, luxuriant, gray, moist. Potato discolored.

Grows at 20° and moderately at 37°. Aerobic.

B. lactis plicatus n. s. *A spore bearing, liquefying bacillus with a folded scum.* Found in Camembert cheese.

Morphology.—Size, 2μ x .8μ–1.2μ. No chains, central spores produced, Gram stain positive, no capsules.

Gelatine colony.—Rapidly liquefying into a non-characteristic cloudy pit.

Gelatine stab.—At first arborescent; liquefies in one day, stratiform; about one third of the gelatine liquefies in ten days, with a white folded scum.

Agar streak.—Nodose, capitate, rugose, opaque, white, luxuriant, moist and wrinkled.

Fermentation tubes.—Dextrose is rendered acid; no gas and no closed arm growth in any sugar bouillon.

Bouillon.—A granular sediment, a turbidity, and a pellicle forms, which subsequently sinks.

Milk.—Becomes alkaline and curdles at 37°, not at 20°. Is subsequently digested.

Potato.—Luxuriant, diffused, thin, smooth, of an orange-white color. Potato is discolored.

Grows at 20° and 37°, but better at 37°. Aerobic.

B. lactis amberis n. s. *A brown fluorescent liquefying bacillus.* Found only in milk from Colchester.

Morphology.—Size, 1μ–1.5μ x 3μ–4μ. No chains, central spores, Gram stain is positive and a capsule is produced.

Gelatine colony.—A non-characteristic, rapidly liquefying colony.

Gelatine stab.—Liquefaction begins in one day, infundibuliform; complete in six days.

Agar streak.—Linear, raised, rugose, translucent, yellowish, moist, wrinkled. The agar with an amber colored or yellow-green fluorescence.

Fermentation tubes.—Dextrose is acid, the other two sugars alkaline. No gas, but a very slight growth in closed arm.

Bouillon.—A flocculent sediment, a slight turbidity, but no pellicle.

Milk.—No change in reaction. Curdled in one to two days, and digested both at 20° and 37°. Digestion is nearly complete in three weeks.

Potato.—Linear, raised, smooth, yellowish, dry, luxuriant; potato discolored.

Grows at 20° and 37°. Facultative anaerobic.

The last two organisms are very closely related and may be identical. The amber colored fluorescence and the yellow pigment lead us to separate the two.

B. mesentericus fuscus n. s. *A brown, spore-bearing acid liquefier.* Found only once in milk, directly from the udder.

Morphology.—A peritrichic bacillus which does not form chains. Size, 1.2μ–1.5μ x .4μ–.6μ. It stains by Gram method and produces central spores.

Gelatine colony.—A round, convex, smooth, entire colony, of a brownish-red color. On *litmus gelatine* it is acid.

Gelatine stab.—A slow liquefaction, napiform.

Agar streak.—Spreading, thin, rugose, translucent, gray, luxuriant, dull, and wrinkled.

Fermentation tubes.—Dextrose and saccharose rendered acid, but no gas nor closed arm growth in any sugar bouillon.

Bouillon.—A slight turbidity is produced, although sometimes even this is wanting. No sediment, nor pellicle.

Milk.—Rendered slightly alkaline, and curdles in six days at 37°. The milk is digested, although this power of digestion was lost after long cultivation.

Potato.—A luxuriant, spreading, thin, rugose growth, of a brown-red color, wrinkled.

Grows better at 37° than at 20°. Aerobic.

B. lactis vinus n. s. *A spore-bearing, acid liquefier.* This has been found but once, in milk in Middletown.

Morphology.—1μ–1.2μ x .6μ. No chains. Spores are produced, no capsules, and Gram stain is negative.

Gelatine colony.—A very rapidly liquefying colony with a slight granular liquid. Not characteristic.

Gelatine stab.—A needle growth, liquefying in one day, infundibuliform; complete in eight days.

Agar streak.—Scanty, linear, thin, smooth, opalescent, gray, moist.

Fermentation tubes.—All three sugar bouillons show acidity and growth in the closed arm, but no gas.

Bouillon.—An amorphous sediment and a slight turbidity, but no pellicle.

Milk.—Becomes acid, and curdles at 20° and 37°, and subsequently digests, giving a clear whey, with a vinous odor.

Potato.—Scanty, linear, thin, smooth. Potato not discolored.

Grows at 20° and 37°, but better at 20°. Facultative anaerobic.

Close to this belong the butyric acid organisms of Prazmowski, Hueppe and Botkin. We have not studied them.

B. lactis Pruchii n. s. *A slimy milk, peritrichic bacillus.* This peculiar bacterium was sent from Geneva. Its remarkable involution forms, and its other unique characters clearly distinguish it, although it was lost before we had quite completed our work upon it.

Morphology.—A spore-producing, peritrichic bacillus, with no capsule. It does not accept the Gram stain. Involution forms, curved, club shaped, and showing other irregularities, are common.

Gelatine colony.—A rapidly liquefying pit, not characteristic.

Gelatine stab.—Liquefies in one day, stratiform, with a turbid liquid, and a reddish-yellow sediment.

Agar streak.—Round, flat, smooth, opaque, white, luxuriant and viscous. No fluorescence is seen, although milk is turned green.

Fermentation tubes.—Dextrose bouillon is rendered acid. No gas and no closed arm growth in any bouillon.

Bouillon.—A viscous sediment, a turbidity, and a flocculent pellicle.

Milk.—Is rendered acid, is curdled and digested at both 20° and 37°, with a slight yellowish color. Later it becomes quite yellow and slimy.

Potato.—Spreading, thin, smooth, brownish, luxuriant. Potato discolored.

Grows at both 20° and 37°. Anaerobic.

B. lactis fungiformis n. s. *A white, rhizoid, spore-producing bacillus.* This has been found in fresh milk and stable dust several times. The different cultures show slight variations, indicated within brackets.

Morphology.—Size, 3μ–3.5μ x 1.3μ. No chains. Spores are developed and an evident capsule. The Gram stain is positive.

Gelatine colony.—The colony throws out fibers like a mold, but after two days this character disappears, the colonies disintegrating into a liquefying pit. On *litmus gelatine* this character is not evident.

Gelatine stab. Liquefaction begins in two days, but never becomes complete. Infundibuliform.

Agar streak. Filiform, raised, grumose, translucent, porcelain white, dull [wrinkled].

Fermentation tubes.—Dextrose is acid, the other two sugar bouillons alkaline. Growth in closed arm in all cases, and no gas. [Dextrose and saccharose alkaline; lactose acid.]

Bouillon.—A sediment, a granular pellicle, and no turbidity. [Turbidity.]

Milk.—Becomes alkaline, curdles and digests with a strong odor. [Acid, otherwise as above, except that the milk is brownish.]

Potato.—Luxuriant, rather thick, rough, white.

Grows at 20° and 37°. Facultative anaerobic.

Variety A.—Agrees in all points except that the mold-like colony is not evident, the colony liquefying very rapidly.

II. No Pigment, but Acid in Dextrose and other Sugars.

We have found at least three *liquefying gas producers.* Two of them are quite similar to *B. cloacae*, while the other is closely related to it. The characters as made out by us are as follows:

B. lactis cloacae n. s. *A gas-producing, liquefying bacillus.*

Morphology.—Size, 1μ–1.3μ x .7μ. No chains are formed. The organism accepts the Gram stain, and has a capsule, but produces no spores.

Gelatine colony.—A slow liquefier, forming a dense granular pit. In *litmus gelatine.* there is no acid.

Gelatine stab.—Begins to liquefy in one day and is completely liquefied in six days. Liquefaction deep infundibuliform.

Agar streak.—Filiform, raised, smooth, cream-white or yellowish, iridescent, luxuriant.

Fermentation tubes.—All three sugars rendered acid and show growth in the closed arm. Gas produced in dextrose and saccharose only.

Bouillon.—A sediment, turbidity, and a pellicle.

Milk.—Rendered acid, curdled, and subsequently digested at 20° but not at 37°, showing a yellow color.

Potato.—A scanty, thin, irregular, white growth.

Grows better at 20° than at 37°. Facultative anaerobic.

B. lactis cloacae A. n. s. This was found in milk in this vicinity, but an almost identical organism was sent us by Weigmann from Kiel, labeled *aerogenes.* It is clearly not that specie, since it liquefies gelatine. Its characters are as follows:

Morphology.—Size, 1.5μ x .5μ–.6μ. Chains are formed in bouillon. It produces no spores nor capsules, and does not accept the Gram stain.

Gelatine colony.—Round, raised, smooth, grumose, with wavy edge, gray-white. On *litmus gelatine* a good sized, white, acid colony.

Gelatine stab.—A rapid liquefier, infundibuliform, and showing an abundance of gas.

Agar streak.—Filiform, flat, smooth, moist, not abundant.

Fermentation tubes.—All three sugars show acidity, gas, and closed arm growth.

Bouillon.—An amorphous sediment, a slight turbidity, and a granular pellicle.

Milk.—Is rendered acid and curdled, but with no visible signs of digestion. It develops a cheesy odor.

Potato.—The growth is very scanty and white; potato discolored.

A second culture of the same differed in showing digestion of the milk and a more luxuriant growth on potato.

Grows at both 20° and 37.° Facultative anaerobic.

Bacillus (Proteus) vulgaris (Hauser). This is not uncommon in milk. The characteristics are as follows:

Morphology.—Size, 1.2μ–4μ x .6μ. Forming long chains. It shows no spores nor capsules, and does not accept Gram stain.

Gelatine colony.—Very characteristic, showing irregular amoeboid processes, the so called "proteus type".

Gelatine stab.—Begins to liquefy in twelve hours, with liquefaction complete in a few days. Saccate.

Agar streak.—Luxuriant, moist, slimy, glistening, translucent.

Fermentation tubes.—Not determined, but dextrose is doubtless acid and gas is produced.

Milk.—Rendered acid and curdles at 20°. Is subsequently digested, becoming yellowish.

Potato.—A luxuriant, yellowish-white and slimy growth.

B. lactis diffusus n. s. *A pink Bacillus.*

Morphology.—A motile rod. Size, 1μ x .6μ–.9μ. No chains.

Gelatine colony.—Diffuse appearing as a faint cloud made up of microscopic colonies. To the naked eye it appears like a mold; 3mm. in diameter, then liquefying.

Gelatine stab.—A napiform liquefaction, with a cloudy pink liquid. Below the surface it is orange-red.

Agar streak.—A luxuriant, pink, moist, smooth growth.

Fermentation tubes.—Probably acid without gas.

Bouillon.—A sediment and a turbidity but no pellicle. The sediment is red.

Milk.—Becomes acid and curdles after several days. No other change.

Potato.—A luxuriant, bright pink growth. No discoloration.

Grows at 20° and 37°. Aerobic.

B. lactis cochleatus n. s. *A non-gas-producing, peritrichic bacillus, without spores.* This has been observed twice. One culture was sent us from Geneva by Harding and a second was found in milk in Middletown. The following description is from the Geneva culture. The points where our own differ from it are indicated by brackets.

Morphology.—Size, 1.8μ–3μ x .7μ–.9μ. No chains, no spores, no capsules. Gram stain positive. [Negative.]

Gelatine colony.—A curiously lobed colony, cochleate, rather slowly liquefying. *Litmus gelatine* is not acid. The colony is quite characteristic. [A simple lobed, slowly liquefying colony, not cochleate.]

Gelatine stab.—Begins to liquefy in three days, stratiform.

Agar streak.—Linear or spreading, thin, moist, opaque, white or gray, not luxuriant. [Yellowish, luxuriant.]

Fermentation tubes.—Dextrose and saccharose acid, lactose not acid. No gas nor closed arm growth.

Bouillon.—Sediment and turbidity, but no pellicle.

Milk.—Made alkaline and curdled at 37°. Subsequently digested, with a prominent odor.

Potato.—Very scanty, white. [Luxuriant, gray-white, with potato discolored.]

Grows better at 37° than at 20°. Aerobic.

B. lactis Robertii n. s. *A non-gas-producing, acid-forming peritrich.* Found only once.

Morphology.—Size, 1.5μ x .5μ–.8μ. No chains, no spores, no capsule, and Gram stain negative.

Gelatine colony.—A dense, white colony, very slowly liquefying. Is not acid on *litmus gelatine*, but forms a pit colony.

Gelatine stab.—A slow liquefier, stratiform, with a clouded liquid.

Agar streak.—Filiform, thin or thick, smooth, contoured, white, luxuriant.

Fermentation tubes.—Dextrose rendered acid, but no other change in any of the sugar bouillons.

Bouillon.—A flocculent sediment, a turbidity, and a ring formed pellicle.

Milk.—Acid and curdled, but without digestion. The milk develops an odor.

Potato.—A luxuriant, thick, moist, white growth. Potato may be discolored.

Grows at 20° and 37°; better at 20°. Aerobic.

ACID GAS PRODUCERS.

The gas-producing Bacteria and Bacilli constitute, with the exception of the *Bact. lactis acidi* group, the most important dairy organisms. To this group belong many of the most mischievous dairy bacteria. Among them are those that spoil large quantities of cheese by the production of the trouble known as swelling. Sometimes great quantities of cheese are utterly ruined by the development of gas bubbles. The gas bacteria, also, sometimes spoil butter, and they are generally undesirable. Whereas the non-acid-producing bacteria are commonly the dairyman's friends, at least so far as relates to butter and cheese making, the gas-producing bacteria are universally his enemies. In their relation to milk problems they thus form a group by themselves. In their systematic relations they belong to different divisions; some of them are Bacteria,

others are Bacilli. But because of their practical association together in dairy problems, we think it more convenient to consider them all in one group, only referring to them in their logical place in our scheme of classification. The other gas producers, clearly not related to these, are described under the different groups where they belong.

Two somewhat extensive studies of the acid-producing, rod-shaped bacteria have been made besides our own. One of these was by Harrison, who studied fifty-six different cultures (Cent. f. Bac. II., XIV. 359, 1905), and the second by Gruber who carefully studied thirty-seven cultures (Cent. f. Bac. II., XVI. 654, 1906). Although these differ in some slight respects, the general conclusion from their study is in essential agreement with our own. There exists a long series of these forms that show slight variations, which grade into each other in such a way as to make it, at present at least, out of the question to arrange them all in any logical scheme even if it were worth while. Both Harrison and Gruber agree that all of these types may be arranged between two extremes, represented by *Bact. lactis aerogenes* and *B. coli communis*. The essential differences of the extremes are as follows: *B. lactis aerogenes* is non-motile, produces no indol, and has a thick colony on gelatine; *B. coli communis* is motile, produces indol, and a thin colony. But even these primary characters cross each other more or less, especially those of indol production and the type of colony, so that they cannot be regarded as especially characteristic. Indeed, almost any combination of the above characters as well as others can be found among the many cultures that have been studied.

Whether, under these conditions, it is worth while to attempt any classification may well be doubted. Harrison does divide them into a series of groups without, however, implying that his groups have any diagnostic significance. In doing this he recognizes all the variations he can find between the different cultures studied, with a result of making a confusing series of types that clearly have no very great value.

Gruber endeavors further to divide these organisms into groups by their power of fermenting a long series of carbohydrates, and finds it possible to recognize four types. But each of the four is found among both the *aerogenes* and the *coli* type, so that the plan is not particularly useful, quite independent of the fact that no other observer has made test with this long list of sugars.

The sum and substance of the matter is, that there is no means at our command at present by which we may satisfactorily group these types into definite subdivisions. The plan we have adopted is very simple. We recognize, first, the typical *aerogenes* type, under which we have referred to a number of the variations that are known to occur. Then we recognize a type with flagella, but with the typical luxuriant *aerogenes* colony. Third, a type with the typical *coli* characters but monotrichic, and lastly, the typical *coli* form with its peritrichic flagella.

Gruber states that in the *coli* types studied by him, the flagella were always monotrichic and that the name Bacillus should be changed to Pseudomonas. In our own work we have found both the monotrichic type and the peritrichic type. The peritrichic type has appeared far more frequently than the monotrichic type, but the latter has been found quite a number of times. Whether these modifications are the same or really two different types of *coli*, we do not

venture to determine at present. We think the best course to pursue is to recognize the two as different, and we have consequently done so in our classification.

The following classification is based upon the work of Harrison and Gruber, with the aid of such additional data as we have ourselves obtained.

BACT. AEROGENES TYPE.

This organism has appeared in literature under a long list of names. The organisms of the following list appear to be identical with each other and are of this type. *B. pyogenes* (Albarran), *Bact. aceticum* (Baginsky), *Bact. theloideum* (Gassner), *Bact. ubiquitous* (Jordan), *Bact. candicans* (Frankland), *Bact. zurnianum* (List), *B. capsulatus* (Smith), *B. chologens* (Stern), *B. acidi laevolactici* (Kozai). It is by no means certain that these organisms are identical, but the descriptions given of them agree so closely as to lead to the conclusion that they are essentially the same. The general characters of this type are as follows:

Bact. lactis aerogenes (Esch.). *The non-motile, acid, gas producers.*

Morphology.—Size, 1.4μ–5μ x 1μ–1.5μ. There are no chains, no spores, and no flagella. A capsule is frequently found and the Gram stain is variable.

Gelatine colony.—Large colonies, 2 mm. in diameter, thick, round, smooth, moist, sometimes viscous. On *litmus gelatine* they are essentially the same, and very strongly acid. They frequently show bubbles of gas under the surface of the gelatine.

Gelatine stab.—A good needle growth, and a thick white surface. If sugar is present, gas bubbles may appear.

Agar streak.—Luxuriant, moist, gray-white, smooth.

Fermentation tubes.—All sugar bouillons show acidity, closed arm growth, and an abundance of gas.

Bouillon.—A turbidity and a sediment, and commonly a pellicle.

Milk.—Becomes strongly acid, and curdles, bubbles of gas being commonly evident. This curd is usually very different in appearance from that produced by *Bact. lactic acidi.*

Potato.—Luxuriant, of a dirty-white to straw color.

Grows at both 20° and 37°, but better at 37°. Aerobic. Indol is not produced.

Twenty-three of Harrison's organisms belong to this general type, and we have ourselves found it extremely common.

Among the varieties of this typical form which appear among the many cultures studied, we make special reference to the following:

Variety A.—Produces indol. Among the different cultures belonging here some produce the typical thick, aerogenes colony, and some the thinner umbonate colony with a smooth center.

Variety B. Produces no indol, but has a thick colony more like that of coli. Among them are some which produce no acidity in saccharose, and do not curdle milk, and others that ferment all of the ordinarily used sugars.

Varieties C. and D. These two differ from common aerogenes bacteria in making *milk bitter*. They also show some other rather peculiar characters, although they plainly belong to the aerogenes type. Variety C was isolated by ourselves from milk in Connecticut and differs from the type in the following points: the litmus gelatine is not acid; a brown fluorescence is produced on agar; dextrose is acid, but no gas is produced; milk is curdled at 37° only, and is very bitter; potato growth is very luxuriant, white, and the potato is discolored.

Variety D, sent us by Harding, produces gas in dextrose only, but all three sugar bouillons become slimy; there is no closed arm growth, no pellicle on bouillon; milk bitter; potato growth is luxuriant and the potato is discolored.

THE COLI COMMUNIS TYPE.

The rest of the gas producers found in milk are flagellates. Among them we recognize some with thick colonies, like *aerogenes*, and others with thinner, spreading colonies, of the *coli* type. In most cases the flagella are peritrichic, but there is one type found by us several times that is monotrichic. Beginning first with the types most similar to *aerogenes*, we recognize the following varieties:

B. coli aerogenes n. s.

Morphology.—Size, 1μ–3μ x 1μ–1.4μ. There are no chains nor spores; Gram stain is negative, and the bacilli are peritrichic.

Gelatine colony.—Prominent, thick, moist, smooth, large, surface colonies.

Gelatine stab.—A needle growth, and a thick, white surface growth.

Agar streak.—Filiform, raised, smooth, opaque, cream-white to brown.

Fermentation tubes.—All three sugars are rendered acid, gas is produced, and there is growth in the closed arm. The amount of gas is not very great.

Bouillon.—A sediment and turbidity, and usually a pellicle.

Milk.—Rendered strongly acid and curdled with gas bubbles.

Potato.—White to straw color, luxuriant.

Grows at both 20° and 37°, better at 37°. Aerobic. Indol is produced.

Some twenty of Harrison's organisms would belong here. They differ among themselves very much in their gelatine colonies, and somewhat in their growth on agar. There are also differences in their powers of fermenting different sugars. We do not see in these points any good reasons for separating them. One variety, however, may be properly recognized in accordance with the plan adopted above.

Variety A.—Produces no indol.

Here apparently belongs *B. Schafferi.*

B. coli communis (Esch.) This differs from the last chiefly in producing a thinner colony on gelatine, which is umbonate, and has a granular, lobate edge. Its agar growth is smooth and white. Upon potato it does not usually grow luxuriantly, and indol is produced.

B. coli is very common in milk, as would be expected from the frequency of fecal contamination. The distinction between this and the last type is not sharp, and perhaps should not be recognized as marking separate types. The organisms which we have called *aerocoli* seem to be in a measure intermediate between *aerogenes* and *coli*, a fact further suggested by the study of some cultures sent me by Weigmann and labeled *aerogenes*. These were distinctly motile and peritrichic when studied by us, suggesting that either the presence of flagella has not always been regarded as diagnostic for separating coli and aerogenes, or that a non-flagellate type may later develop flagelli. The typical characters of this group are as follows:

B. coli communis.

Morphology.—Size, 1μ–1.6μ x .4μ–1μ. No chains, no spores, no capsules. Gram stain negative. Flagella peritrichic.

Gelatine colony.—A rather thin, spreading colony, umbonate, with a smooth center, granular edge, lobate. *Litmus gelatine* shows a dense white colony, which is decidedly acid, and may show gas bubbles.

Gelatine stab.—A filiform needle growth, with a spreading, moderately thick surface growth.

Agar streak.—Filiform, raised, smooth, sometimes lobate, opaque, white, moist.

Fermentation tubes.—All three sugars are rendered acid and develop gas. They also show growth in closed arm. The amount of gas is somewhat variable, and the proportion of hydrogen and carbon dioxide is approximately two to one, but quite variable.

Bouillon.—An abundant turbidity, a sediment, and commonly a ring-formed pellicle.

Milk.—Is rendered acid and curdled. The curdling is not absolutely constant, however. Sometimes the milk does not curdle till after it is boiled. There is never any digestion, but a whey may separate from the curd.

Potato.—A moderate, smooth, gray-white growth, sometimes luxuriant.

Grows both at 20° and 37°, but better at 37°. Aerobic. Indol is produced.

Variety A. Agrees with the type except that it fails to produce gas in saccharose or lactose.

Variety B. This differs from the typical coli chiefly in its action on milk, which it turns acid with a viscous coagulum. This is extremely slimy. Its colony is umbonate and tenacious, and can only be removed from the gelatine as a whole. In other respects it agrees with coli. Harrison regards it as *aerogenes*, but since it is motile, it must be grouped here.

Ps. coli communis n. s. *A gas-producing, non-liquefying Pseudomonas.* This organism and two sub-varieties were all found in cheese made at this place. They are probably physiological varieties of the same organism. Varieties C and D came from the same colony and are interesting, therefore, as showing a possibility of physiological variations from the same culture.

Morphology.—Size, 1μ–1.5μ x .8μ–.9μ. No spores, no chains, no capsules; Gram stain negative.

Gelatine colony.—A round, thick, smooth, or contoured, auriculate colony, of a gray color. On *litmus gelatine* a large surface colony is produced, strongly acid, and with a gas bubble. Resembles *B. lactis aerogenes*. In some cultures it is thinner and of the coli type.

Gelatine stab.—A filiform growth, and an umbonate surface, with a bluish sheen over the surface.

Agar streak.—Not luxuriant, linear, raised, smooth, gray.

Fermentation tubes.—Acidity, gas, and closed arm growth in all three sugar bouillons.

Bouillon.—A sediment, decided turbidity, and a flocculent pellicle.

Milk.—Rendered acid and curdled at 37°. No digestion, but a prominent odor.

Potato.—Moderately luxuriant, thin, spreading, gray.

Grows better at 20° than at 37°. Facultative anaerobic.

Variety A differs from the above in the following points:

Variety A. Size, 1μ x .5μ. Flagellum very long. Gelatine stab, spreads from needle track below surface. Agar, luxuriant. Milk, curdled.

Variety B. Size, 1.2μ x .5μ. Gelatine colony, thin, transparent. Not acid on litmus gelatine. No acidity nor gas in lactose or saccharose, but showing closed arm growth. Potato, growth thin, cream-white.

These organisms are in nearly every respect identical with *B. coli communis*, except that they have one flagellum instead of many. This flagellum is very long and characteristic.

CLASSIFICATION OF DAIRY BACTERIA.

Bacteria that are spherical in form, - *Coccaceae.*
Bacteria that are rod-shaped, - - *Bacilliaceae.*

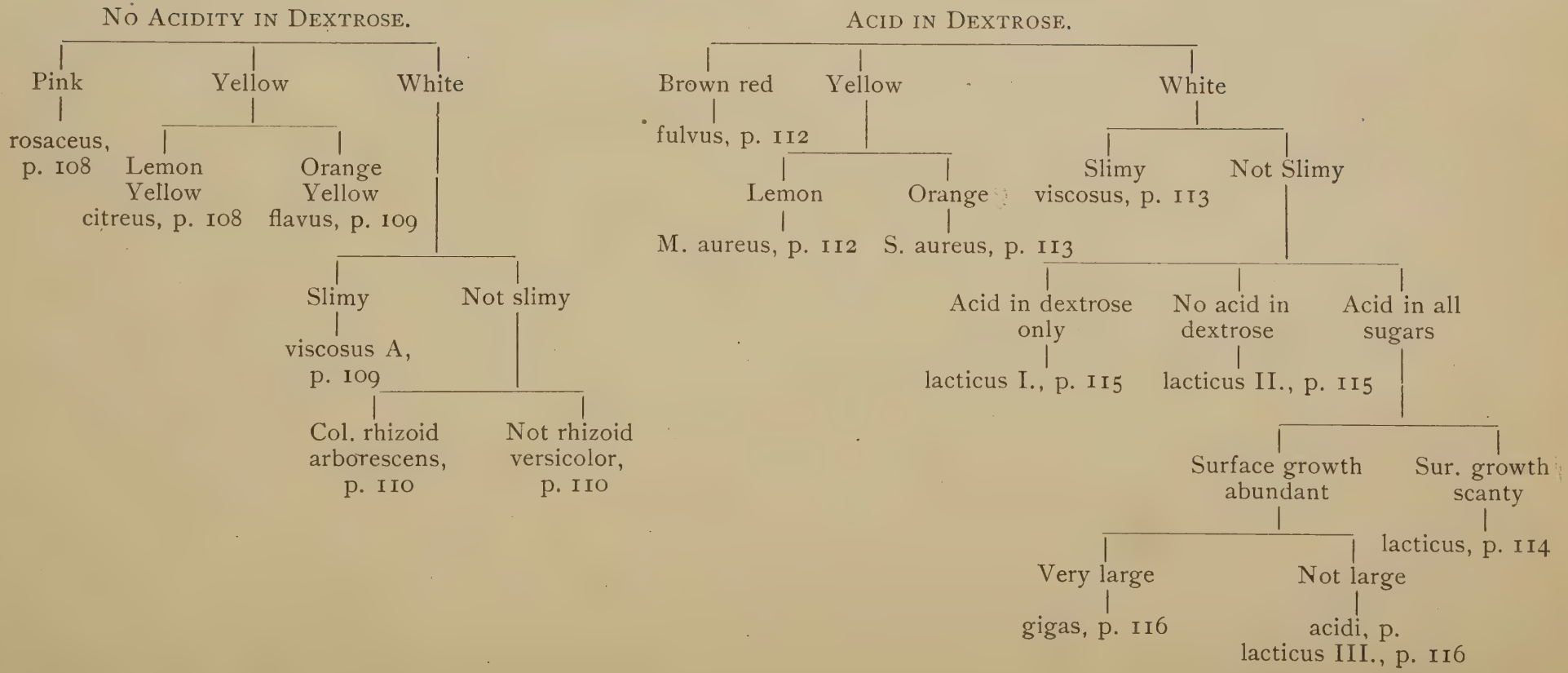
Coccaceae.

Coccus forms that do not liquefy gelatine, - - 108, 188
Coccus forms that liquefy gelatine, - - - 117, 189
Sarcina type, - - - - - - - - 124

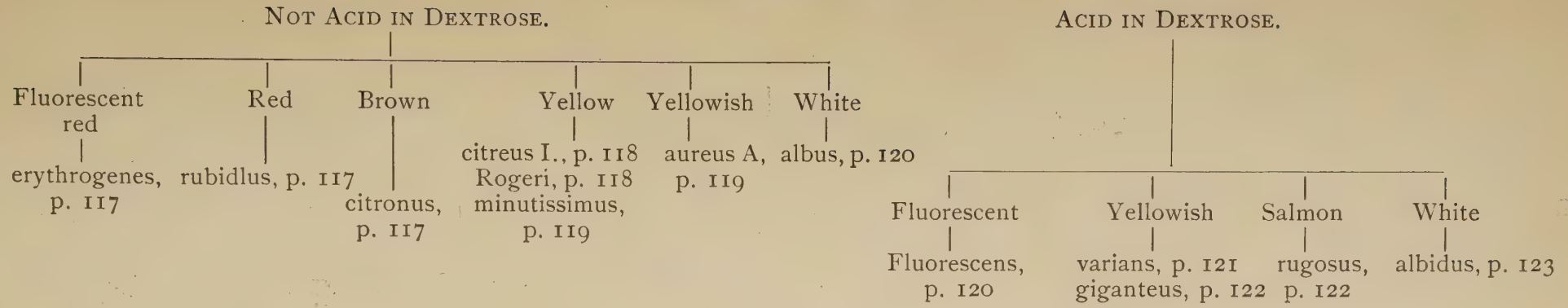
Bacilliaceae.

Non-flagellate rods (Bacterium), - - - - - I.
Flagellate rods (Bacillus) - - - - - - II.
Bacteria and Bacilli which produce acid and gas, - - 182
I. Bacteria that liquefy gelatine, - - - - 136, 190
Bacteria that do not liquefy gelatine, - - 125, 189
II. Bacilli with flagella over the whole body (Peritrichic), 164
Bacilli with a single polar flagellum (Monotrichic), 150, 191
Bacilli with a tuft of flagella at the end (Lophotrichic), 159, 191

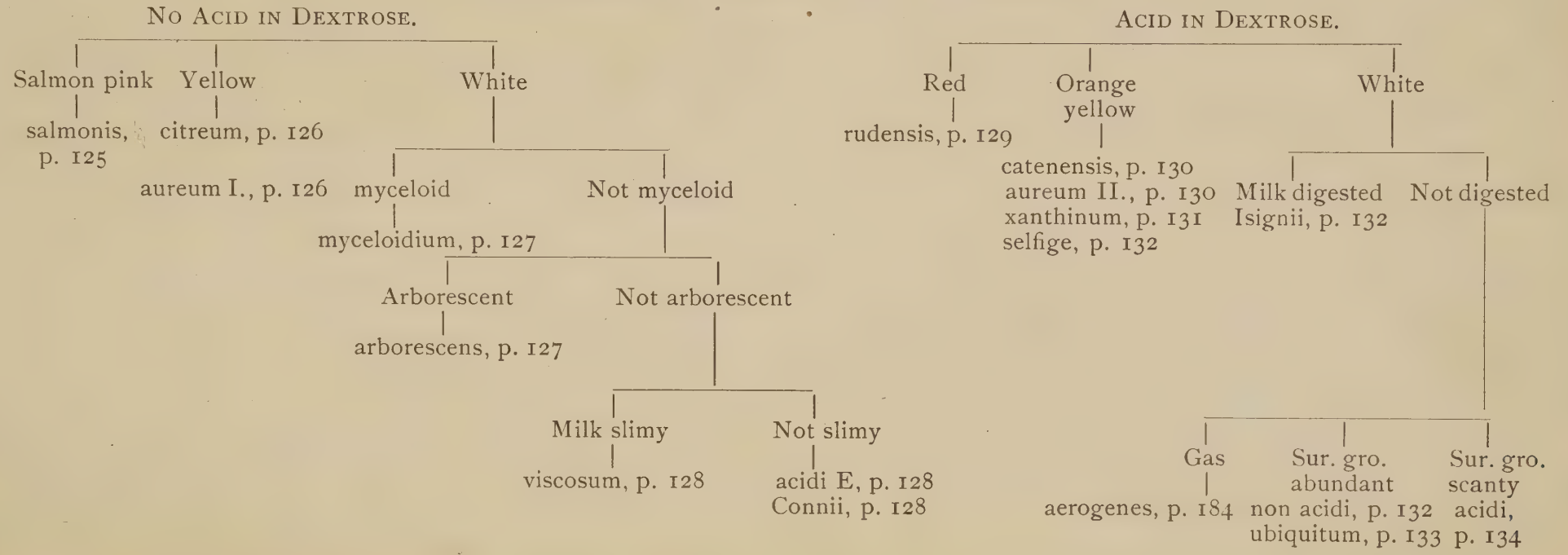
Non-liquefying Cocci.



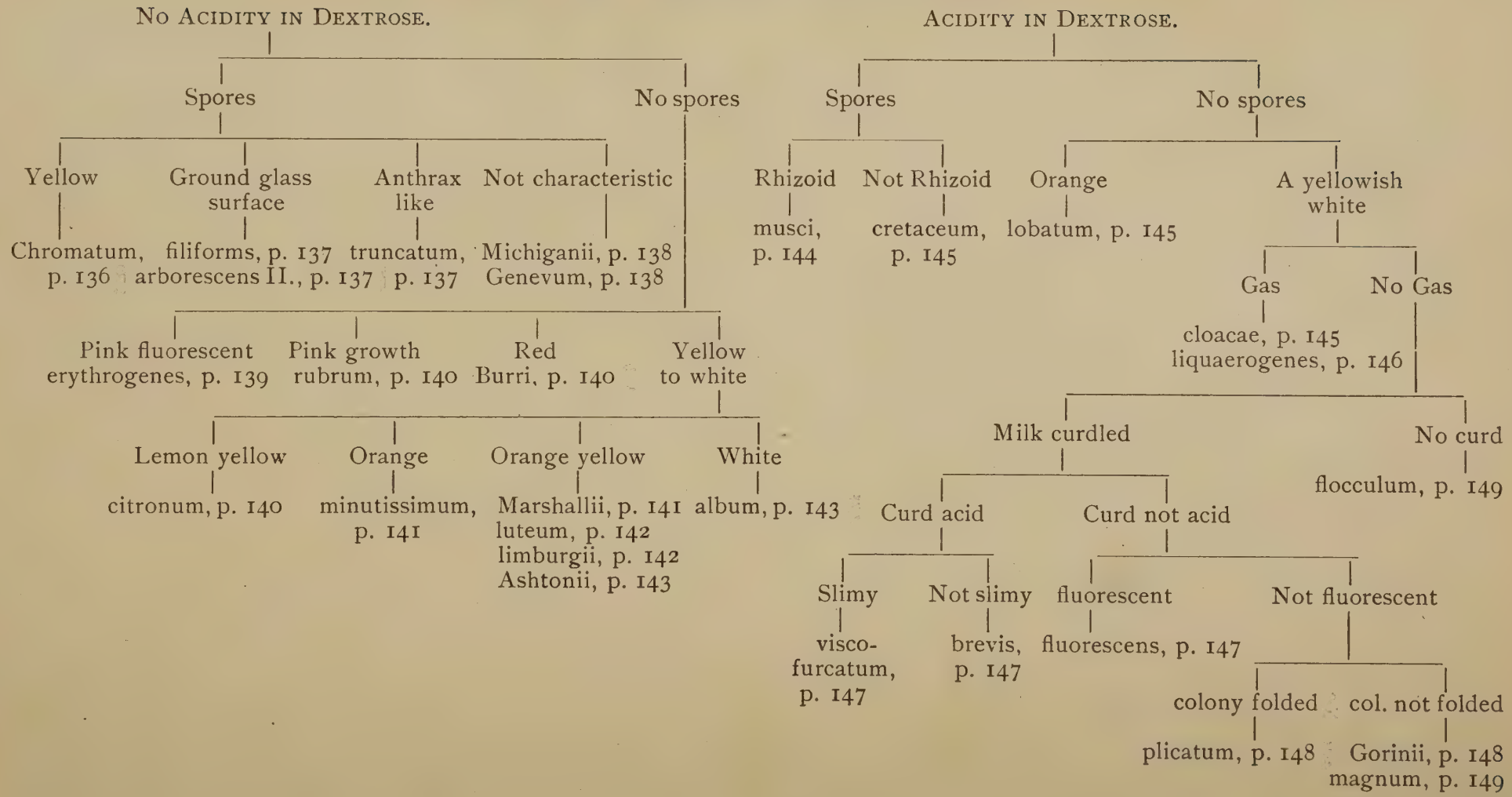
Liquefying Cocci.



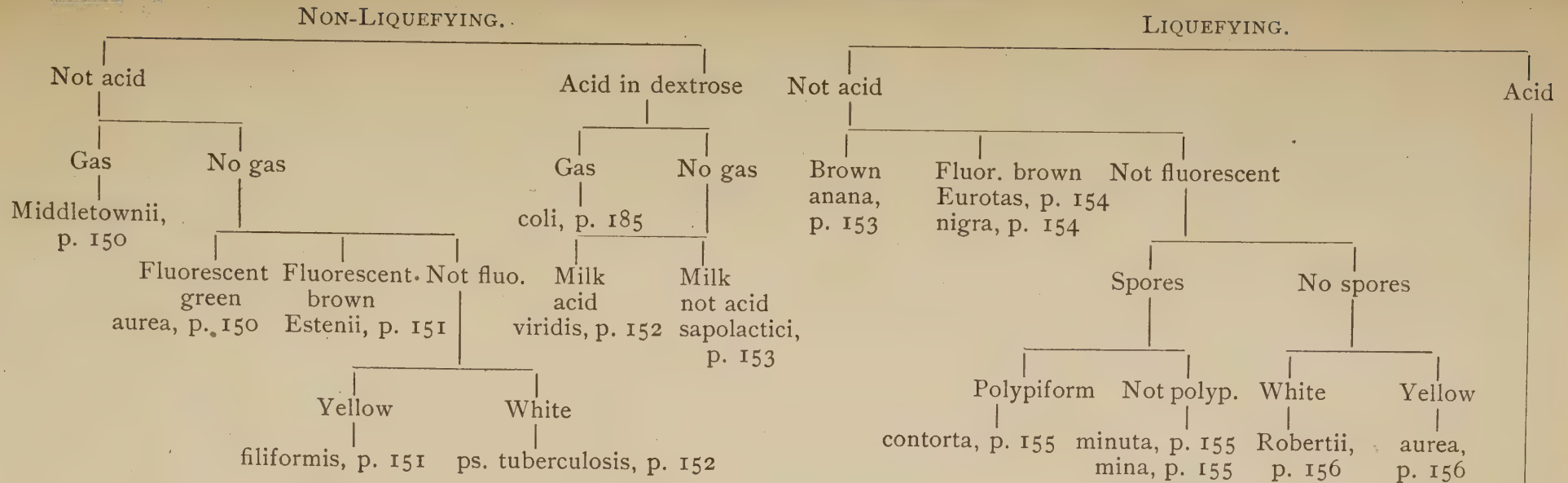
Non-liquefying, non-motile rods=Bacterium.



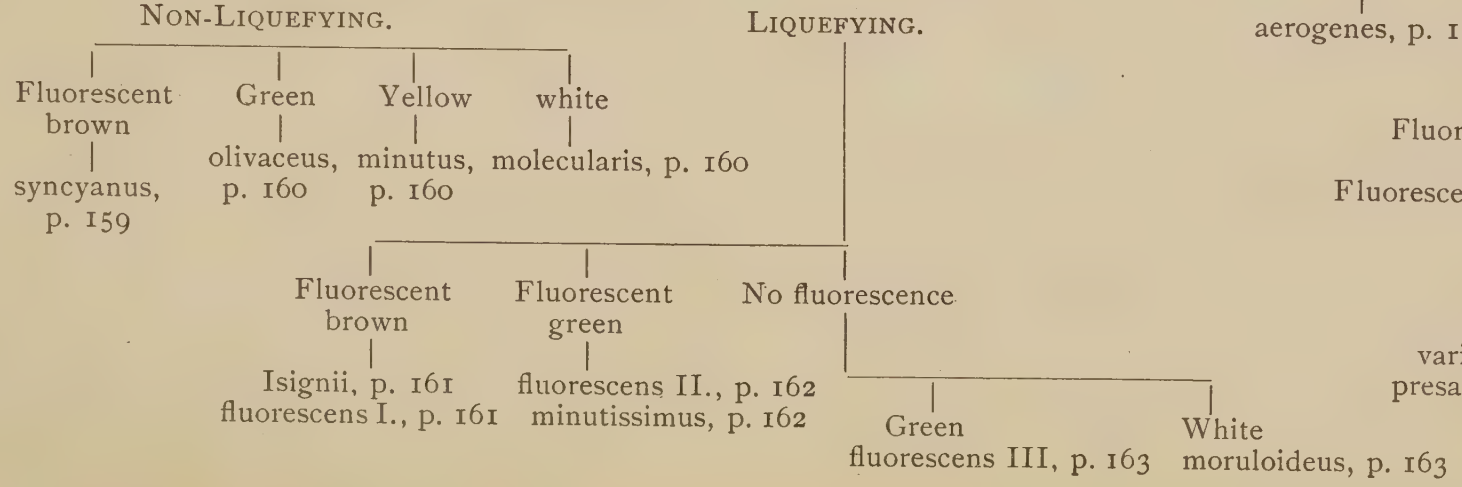
Non-motile, liquefying rods=Bacterium.



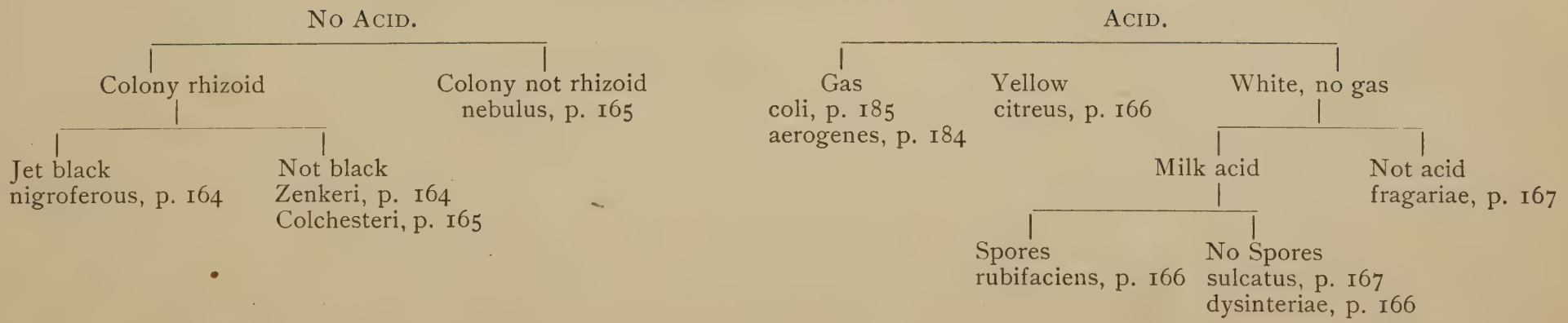
Monotrichic Bacilli=Pseudomonas



Lophotrichic Bacilli.



Non-Liquefying Peritrichic Bacilli.



Liquefying Peritrichic Bacilli.

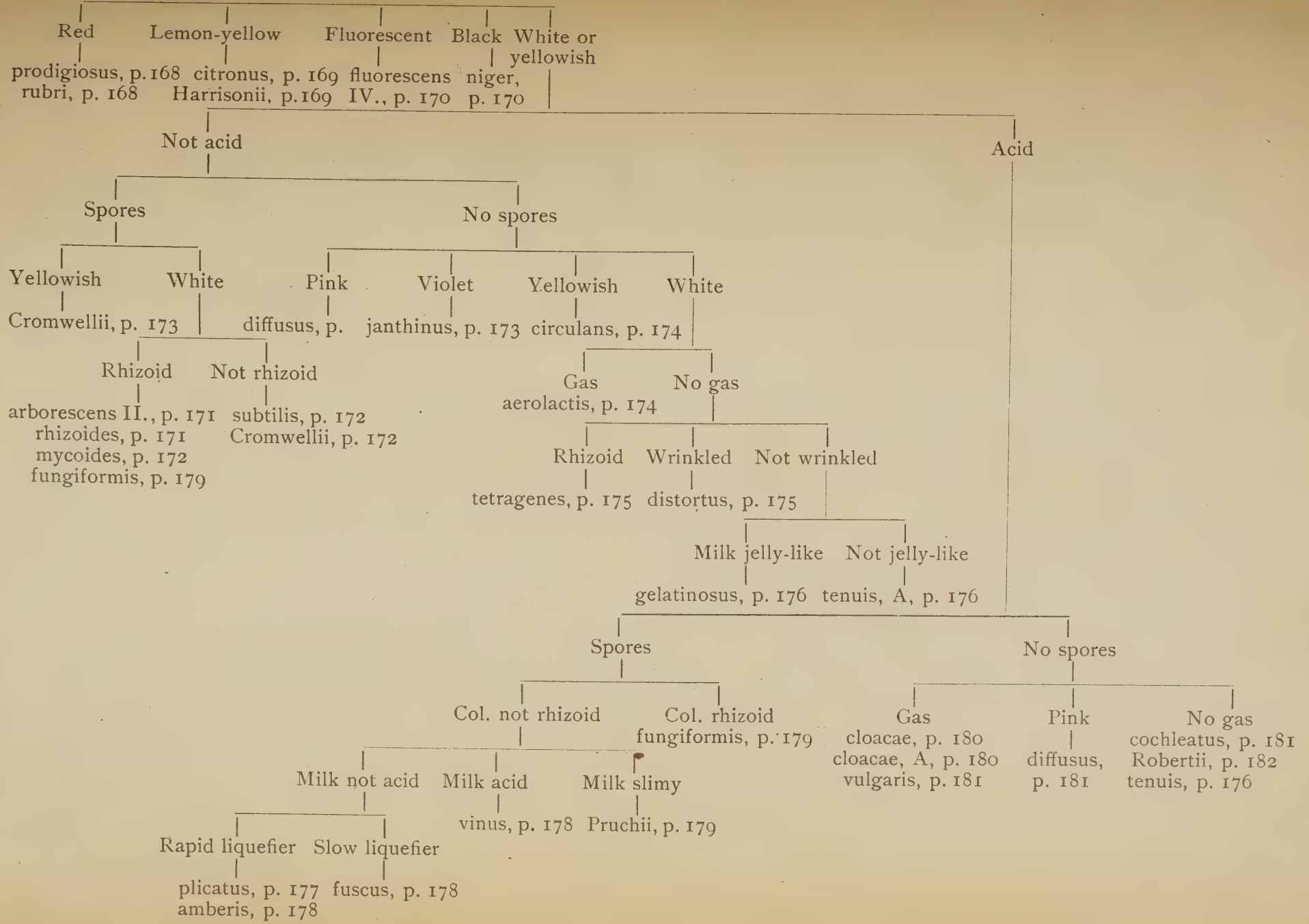


TABLE I.—*Coccaceae.*

GROUP NUMBER.	MORPHOLOGY.					CULTURAL FEATURES.																BIO-CHEMICAL.						NAME.
						Broth.			Agar.			Gel. Plate.					Gel. Stab.			Po-tato.			Lique-faction.			Milk.			
	Diameter over 1 μ.	Chains.	Spores.	Motility.	Gram stain.	Turbidity.	Scum.	Sediment.	Dull.	Wrinkled.	Chromogenesis.	Round-compact.	Proteus-like.	Rhizoid.	Filamentous.	Curled.	Funnel.	Surface growth.	Needle growth.	Abundant.	Discolored.	Grows at 37°.	Gelatine.	Casein.	Blood serum.	Curdled.	Acid.	Alkaline.	Indol.	
212.33307, - - -	—	—	—	—	+	+	—	+	—	—	+	+	—	—	—	—	—	+	+	+	. .	+	—	—	—	—	+	—	. .	M. lactis rosaceus, p. 108
212.33305, - - -	—	—	—	—	+	+	+	+	—	—	+	+	—	—	—	—	—	+	+	+	+	+	—	—	—	—	+	—	. .	M. lactis citreus, p. 108
212.33306, - - -	—	—	—	—	+	+	+	+	—	—	+	+	—	—	—	—	—	+	+	+	. .	+	—	—	—	—	+	—	. .	M. lactis flavus, p. 109
212.33300, - - -	—	—	—	—	. .	+	+	+	—	—	—	+	—	—	—	—	—	+	+	+	+	+	—	—	—	—	—	—	. .	M. lactis viscosus C, p. 109
212.33300, - - -	—	—	—	—	+	+	—	+	—	—	—	+	—	+	—	—	—	+	+	—	—	+	—	—	—	—	—	—	. .	M. lactis arborescens, p. 110
212.33300, - - -	±	+	—	—	+	+	—	+	—	—	—	+	—	—	—	—	—	+	+	—	—	+	—	—	—	—	±	—	. .	G. versicolor, p. 110
212.22208, - - -	—	+	—	—	+	+	—	+	—	—	+	+	—	—	—	—	—	+	+	+	—	+	—	—	—	+	+	—	. .	S. lactis fulvus, p. 112
212.22205, - - -	±	—	—	—	+	+	±	+	—	—	+	+	—	—	—	—	—	+	+	+	+	+	—	—	—	±	+	—	. .	M. lactis aureus, p. 112
212.22206, - - -	+	+	—	—	+	+	+	+	±	±	+	+	—	—	—	—	—	+	+	+	+	+	—	—	—	±	±	—	. .	S. lactis aureus, p. 113
212.22200, - - -	+	+	—	—	—	+	+	+	—	—	—	+	—	—	—	—	—	+	+	+	—	+	—	—	—	+	+	—	. .	S. lactis viscosus, p. 113
212.23300, - - -	±	+	—	—	+	+	+	+	—	—	—	+	—	—	—	—	—	+	+	—	—	+	—	—	—	—	±	—	. .	S. lactis lacticus I. and II., p. 115
212.22200, - - -	+	—	—	—	+	—	—	+	—	—	—	+	—	—	—	—	—	—	+	—	—	+	—	—	—	+	+	—	. .	M. lactis gigas, p. 116
212.22200, - - -	±	—	—	—	+	+	—	+	—	—	—	+	—	—	—	—	—	+	+	—	—	+	—	—	—	—	±	—	. .	M. lactis acidi, p. 116
212.22200, - - -	—	+	—	—	+	+	—	+	—	—	—	+	—	—	—	—	—	—	+	—	—	+	—	—	—	+	+	—	. .	S. lactis lacticus, p. 114
211.33301, - - -	—	—	—	—	. .	+	—	+	+	+	+	+	—	—	—	—	—	+	—	+	+	+	+	+	. .	+	—	+	. .	M. lactis erythrogenes, p. 117
211.33307, - - -	—	—	—	—	. .	+	—	+	—	—	+	+	—	—	—	—	+	—	—	—	+	+	+	+	. .	—	—	+	. .	M. lactis rubidus, p. 117
211.33306, - - -	—	—	—	—	+	+	+	+	—	—	+	+	—	—	—	—	—	—	—	+	+	+	+	—	. .	—	—	—	. .	M. lactis citronus, p. 117
211.33305, - - -	—	+	—	—	+	+	+	+	—	—	+	+	—	—	—	—	—	—	—	+	—	+	+	+	. .	—	—	—	. .	S. lactis citreus, p. 118
211.33305, - - -	—	+	—	—	±	+	—	+	—	—	+	+	—	—	—	—	—	. .	. .	+	+	+	+	+	. .	±	—	+	. .	S. lactis Rogeri, p. 118
211.33305, - - -	—	—	—	—	—	+	—	+	—	—	+	+	—	—	—	—	+	—	+	+	—	±	+	+	. .	+	—	—	. .	M. lactis minutissimus, p. 119
211.33305, - - -	—	—	—	—	+	+	+	—	—	—	+	+	—	—	—	—	+	—	+	+	—	+	+	+	. .	+	—	+	. .	M. lactis aureus A, p. 119
211.33305, - - -	—	—	—	—	+	+	—	+	—	—	—	+	—	—	—	—	+	+	+	+	—	+	+	+	. .	—	—	+	. .	M. lactis albus, p. 120
221.23301, - - -	—	—	—	—	—	+	+	+	—	—	+	+	—	—	—	—	—	—	+	—	—	+	+	+	. .	+	+	—	. .	M. lactis fluorescens, p. 120
221.22205, - - -	±	—	—	—	+	+	±	+	+	—	+	+	—	—	—	—	—	+	—	+	—	+	+	+	. .	+	+	—	. .	M. lactis varians, p. 121
211.22206, - - -	+	—	—	—	+	+	—	—	—	—	+	+	—	—	—	—	+	—	+	—	—	+	+	+	. .	+	+	—	. .	M. lactis giganteus, p. 122
211.???06, - - -	+	—	—	—	±	+	+	+	+	+	+	+	—	—	—	—	+	—	+	. .	. .	+	+	—	. .	+	+	—	. .	M. lactis rugosus, p. 122
211.22200, - - -	±	—	—	—	+	+	—	+	—	—	—	+	—	—	—	—	+	+	+	+	—	+	+	+	. .	+	±	—	. .	M. lactis albidus, p. 123

TABLE 2.—*Bacterium, Non-Liquefying.*

GROUP NUMBER.	MORPHOLOGY.					CULTURAL FEATURES.																	BIO-CHEMICAL.						NAME.
						Broth.			Agar.			Gel. Plate.					Gel. Stab.			Po-tato.			Lique-faction.			Milk.			
	Diameter over 1 μ.	Chains.	Spores.	Motility.	Gram stain.	Turbidity.	Scum.	Sediment.	Dull.	Wrinkled.	Chromogenesis.	Round-compact.	Proteus-like.	Rhizoid.	Filamentous.	Curled.	Funnel.	Surface growth.	Needle growth.	Abundant.	Discolored.	Grows at 37°.	Gelatine.	Casein.	Blood serum.	Curdled.	Acid.	Alkaline.	Indol.	
212.33307, - - -	—	—	—	—	+	+	+	+	—	—	+	+	—	—	—	—	—	+	+	+	..	±	—	—	—	—	—	+	..	Bact. lactis salmonis, p. 125
212.33306, - - -	—	+	—	—	+	+	+	+	±	—	+	+	—	—	—	—	—	+	+	+	..	±	—	—	—	—	—	+	..	Bact. lactis aureum I., p. 126
212.33305, - - -	±	+	—	—	+	+	+	+	—	—	+	+	—	—	—	—	—	+	+	+	..	+	—	—	—	—	—	—	..	Bact. lactis citreum, II., p. 126
212.33300, - - -	—	+	—	—	±	+	—	+	—	—	±	+	—	+	—	—	—	+	+	—	..	±	—	—	—	—	±	—	..	Bact. lactis myceloidium, p. 127
212.33300, - - -	—	+	—	—	+	+	±	+	—	—	—	+	—	—	—	—	—	+	+	+	..	+	—	—	—	—	—	+	..	Bact. lactis arborescens, I., p. 127
212.33300, - - -	—	—	—	—	—	—	—	+	—	—	—	+	—	—	—	—	—	—	+	—	—	+	—	—	—	—	—	—	..	Bact. lactis viscosum, p. 128
212.33300, - - -	—	—	—	—	+	+	+	+	—	—	—	+	—	—	—	—	—	+	+	+	+	+	—	—	—	—	—	+	..	Bact. lactis acidi E, p. 128
212.22207, - - -	±	—	—	—	+	+	—	+	—	—	—	+	—	—	—	—	—	±	+	—	..	+	—	—	—	+	+	—	..	Bact. lactis rudensis, p. 129
112.22305, - - -	—	+	+	—	—	+	+	+	—	±	+	+	—	—	—	—	—	+	+	+	..	±	—	—	—	±	±	—	..	Bact. lactis catenensis, p. 130
212.22205, - - -	+	—	—	—	±	+	—	+	—	—	+	+	—	—	—	—	—	+	+	—	..	±	—	—	—	—	—	±	..	Bact. lactis aureus II., p. 130
212.22200, - - -	—	—	—	±	±	+	—	+	—	—	±	+	—	—	—	—	—	+	+	+	+	+	—	—	—	—	+	—	..	Bact. lactis zynxanthum, p. 131
212.22200, - - -	—	—	—	—	—	+	—	+	—	—	±	+	—	—	—	—	±	+	+	+	..	+	±	—	—	—	—	—	..	Bact. seifige milch, p. 132
212.22200, - - -	+	+	—	—	—	+	—	+	—	—	±	+	—	—	—	—	—	+	+	+	..	+	—	+	—	—	+	—	..	Bact. lactis Isignii, p. 132
212.22200, - - -	+	+	—	—	±	+	±	+	—	—	—	+	—	—	—	—	—	+	+	+	..	+	—	—	—	—	—	±	..	Bact. lactis non acidi, p. 132
212.22200, - - -	—	+	—	—	+	+	—	+	—	—	—	+	—	—	—	—	—	+	+	+	..	+	—	—	—	+	+	—	..	Bact. lactis ubiquitum, p. 133
212.22200, - - -	—	±	—	—	+	+	—	+	—	—	—	+	—	—	—	—	—	+	+	—	—	+	—	—	—	+	+	—	..	Bact. lactis acidi, p. 134
212.22200, - - -	—	±	—	—	+	+	+	+	—	—	—	+	—	—	—	—	—	+	+	—	—	+	—	—	—	—	+	—	..	Bact. lactis acidi B, p. 135
212.22300, - - -	—	—	—	—	—	+	—	—	—	—	—	+	—	—	—	—	—	+	+	—	—	+	—	—	—	+	+	—	..	Bact. lactis acidi C, p. 136
																											+	—	..	Bact. lactis acidi D, p. 136

TABLE 3.—*Bacterium, Liquefying.*

GROUP NUMBER.	MORPHOLOGY.					CULTURAL FEATURES.																BIO-CHEMICAL.						NAME.
						Broth.			Agar.			Gel. Plate.					Gel. Stab.			Po-tato.			Lique-faction.			Milk.			
	Diameter over 1 μ.	Chains.	Spores.	Motility.	Gram stain.	Turbidity.	Scum.	Sediment.	Dull.	Wrinkled.	Chromogenesis.	Round-compact.	Proteus-like.	Rhizoid.	Filamentous.	Curled.	Funnel.	Surface growth.	Needle Growth.	Abundant.	Discolored.	Grows at 37°.	Gelatine.	Casein.	Blood serum.	Curdled.	Acid.	Alkaline.	Indol.	
III.33305, - - -	+	+	+	—	..	+	+	+	—	—	+	—	—	—	+	—	+	—	+	+	..	+	+	+	..	+	—	+	..	Bact. lactis chromatum, p. 136
III.23200, - - -	+	+	+	—	—	+	+	+	+	+	—	—	—	+	+	—	+	—	+	+	..	+	+	+	..	+	—	+	..	Bact. lactis arborescens II., p. 137
III.33300, - - -	±	+	+	—	..	—	+	—	—	—	—	—	—	—	—	+	—	+	±	+	..	+	+	+	..	+	—	+	..	Bact. lactis truncatum, p. 137
III.33300, - - -	—	+	+	—	—	+	+	+	—	+	—	+	—	—	—	—	+	—	+	+	..	+	+	+	..	+	—	+	..	Bact. lactis Michiganii, p. 138
III.33300, - - -	+	—	+	—	+	+	+	+	±	—	—	+	—	—	—	—	—	—	+	+	+	+	+	+	..	+	—	+	..	Bact. lactis Genevum, p. 138
221.33305, - - -	±	—	—	—	+	+	+	+	—	—	+	+	—	—	—	—	—	+	+	+	+	+	+	+	..	+	—	—	..	Bact. lactis erythrogenes, p. 139
211.33305, - - -	—	—	—	—	..	—	—	+	+	+	+	+	—	—	—	—	—	+	+	+	..	+	+	+	..	+	—	+	..	Bact. lactis rubrum, p. 140
211.33307, - - -	—	—	—	—	+	+	—	—	—	—	+	+	—	—	—	—	+	—	+	—	—	—	+	—	..	—	+	—	..	Bact. lactis Burri, p. 140
211.33305, - - -	—	+	—	—	+	+	—	+	—	+	+	+	—	—	—	—	+	—	+	+	..	+	+	+	..	±	—	+	..	Bact. lactis citronum, p. 140
III.33305, - - -	+	+	+	—	+	+	—	+	—	+	+	+	—	—	+	—	+	—	+	+	..	+	+	+	..	+	—	+	..	Bact. lactis citronis A, p. 141
211.33305, - - -	—	+	—	—	..	+	+	+	—	—	+	—	—	+	—	—	+	—	+	+	..	±	+	—	..	—	—	+	..	Bact. lactis minutissimum, p. 141
211.33305, - - -	+	—	—	—	—	+	+	+	—	—	+	+	—	—	—	—	+	—	—	+	..	+	+	+	..	—	—	+	..	Bact. lactis Marshalii, p. 141
211.33300, - - -	—	—	—	—	—	+	—	—	—	—	+	+	—	—	—	—	—	+	+	+	..	..	+	+	..	—	—	+	..	Bact. lactis limburgii, p. 142
211.33305, - - -	—	—	—	—	+	+	+	+	+	+	+	+	—	—	—	—	+	—	+	+	..	+	+	—	..	—	—	+	..	Bact. lactis luteum, p. 142
221.33305, - - -	+	—	—	—	±	+	+	+	—	—	+	+	—	—	—	—	+	—	+	+	—	±	+	+	..	+	—	+	..	Bact. lactis Ashtonii, p. 143
211.33300, - - -	—	—	—	—	+	+	+	+	—	—	—	+	—	—	—	—	+	—	—	+	+	+	+	+	..	±	—	+	..	Bact. lactis album, p. 143
III.22300, - - -	±	+	+	—	+	+	±	+	—	+	—	—	—	+	—	—	—	+	+	+	+	+	+	+	..	+	—	—	..	Bact. lactis musci, p. 144
121.23200, - - -	+	—	+	—	+	+	+	+	—	—	—	+	—	—	—	—	±	+	+	+	+	+	+	+	..	+	—	+	..	Bact. lactis cretaceum, p. 145
221.33300, - - -	—	—	—	—	+	+	+	+	—	—	+	+	—	—	—	—	±	—	+	+	..	±	+	+	..	—	+	—	..	Bact. lactis lobatum, p. 145
211.11100, - - -	—	—	—	—	—	+	—	+	+	—	—	+	—	—	—	—	+	+	+	—	+	±	+	—	..	+	+	—	..	Bact. lactis cloacae, p. 145
221.13100, - - -	—	—	—	—	+	+	+	+	—	—	—	+	—	—	—	—	—	—	—	—	+	+	+	+	..	+	—	—	..	Bact. lactis liquaerogenes, p. 146
211.2220?, - - -	—	—	—	—	+	+	—	+	—	—	—	+	—	—	—	—	+	—	—	+	+	+	+	+	..	+	+	—	..	Bact. lactis visco-furcatum, p. 146
221.22200, - - -	—	—	—	—	±	—	—	+	—	—	—	+	—	—	—	—	—	+	+	—	—	+	+	+	..	+	+	—	..	Bact. lactis brevis, p. 147
211.23201, - - -	—	—	—	—	—	+	+	+	—	—	+	?	—	—	—	—	—	+	+	+	..	±	+	+	..	—	+	+	..	Bact. lactis fluorescens, p. 147
221.22200, - - -	—	+	—	—	±	+	—	+	—	—	—	—	—	—	—	?	+	—	+	+	+	+	+	+	..	+	—	+	..	Bact. lactis plicatum, p. 148
211.23200, - - -	±	—	—	—	+	+	+	+	—	—	—	+	—	—	—	—	+	—	+	+	+	+	+	+	..	+	—	+	..	Bact. lactis Gorinii, p. 148
211.23300, - - -	+	+	—	—	+	+	+	+	—	—	—	—	—	—	+	—	—	+	+	+	+	+	+	+	..	+	—	+	..	Bact. lactis magnum, p. 149
211.23300, - - -	±	—	—	—	+	+	+	+	—	—	—	+	—	—	—	—	—	+	+	+	+	±	+	—	..	—	+	—	..	Bact. lactis flocculum, p. 149

TABLE 4.—*Monotrichic Rods=Pseudomonas.*

GROUP NUMBER.	MORPHOLOGY.					CULTURAL FEATURES.																BIO-CHEMICAL.						NAME.
						Broth.			Agar.			Gel. Plate.					Gel. Stab.			Potato.				Liquefaction.			Milk.			
	Diameter over 1 μ.	Chains.	Spores.	Motility.	Gram stain.	Turbidity.	Scum.	Sediment.	Dull.	Wrinkled.	Chromogenesis.	Round-compact.	Proteus-like.	Rhizoid.	Filamentous.	Curled.	Funnel.	Needle growth.	Surface growth.	Abundant.	Discolored.	Grows at 37°.	Gelatine.	Casein.	Blood serum.	Curdled.	Acid.	Alkaline.	Indol.	
222.***01, - -	—	—	—	+	—	+	+	+	—	—	—	+	—	—	—	—	—	+	+	+	+	—	—	—	—	+	+	—	..	Ps. lactis Middletownii, p. 150
212.33301, - -	—	+	—	+	—	+	+	+	—	—	+	+	—	—	—	—	—	+	+	+	+	+	—	—	—	—	—	+	..	Ps. fluorescens aurea, p. 150
212.33301, - -	—	—	—	+	—	+	—	+	—	—	—	+	—	—	—	—	—	+	+	+	—	+	—	—	—	—	—	—	..	Ps. lactis Estenii, p. 151
112.23205, - -	—	+	+	+	—	+	+	+	—	—	+	+	—	—	—	—	—	+	+	+	—	+	—	—	—	—	+	—	..	Ps. lactis filiformis, p. 151
212.33300, - -	—	+	—	+	+	+	+	—	—	—	—	+	—	—	—	—	—	+	+	+	—	+	—	—	—	—	—	—	..	Ps. lactis pseudotuberculosis, p. 152
222.11100, - -	—	—	—	+	—	+	+	+	—	—	—	+	—	—	—	—	..	..	..	+	—	—	—	—	—	—	—	—	..	Ps. coli communis, p. 186
222.23300, - -	—	—	+	+	—	+	—	+	—	—	—	+	—	—	—	—	—	+	+	—	—	+	—	—	—	+	+	—	..	Ps. lactis viridis, p. 152
212.23300, - -	—	—	—	+	—	+	+	+	—	—	—	+	—	—	—	—	—	+	+	—	+	+	—	—	—	—	+	—	..	Ps. sapolactica, p. 153
211.33308, - -	—	+	—	+	—	+	—	+	—	—	+	+	—	—	—	—	+	—	+	+	—	+	+	+	..	+	—	±	..	Ps. lactis anana, p. 153
221.33301, - -	—	—	—	+	—	+	+	+	—	—	—	+	—	—	—	—	—	+	+	+	—	+	+	+	..	+	—	+	..	Ps. lactis Eurotas, p. 154
211.33301, - -	±	—	—	+	—	+	+	+	+	±	—	+	—	—	—	—	+	—	+	+	+	..	+	+	..	+	+	—	..	Ps. lactis nigra, p. 154
121.33300, - -	—	..	+	+	..	+	+	+	—	—	—	—	+	—	—	—	+	+	+	+	—	+	+	+	..	+	—	+	..	Ps. lactis contorta, p. 155
211.33300, - -	—	—	—	+	+	+	—	+	—	—	—	+	—	—	—	—	+	—	+	—	—	+	+	—	..	—	+	—	..	Ps. lactis minuta, p. 155
211.33300, - -	—	..	—	+	—	+	+	+	—	—	—	+	—	—	—	—	+	+	+	+	+	+	+	—	..	—	—	+	..	Ps. lactis mina, p. 155
221.33300, - -	—	—	—	+	+	+	+	+	+	+	—	+	—	—	—	—	—	+	+	+	—	+	+	+	..	+	—	+	..	Ps. lactis Robertii, p. 156
211.33305, - -	±	—	—	+	+	+	+	+	—	—	+	+	—	—	—	—	+	+	+	+	—	±	+	—	..	—	—	+	..	Ps. lactis aurea, p. 156
221.11100, - -	—	—	—	+	—	+	+	+	—	—	—	+	—	—	—	—	—	+	+	—	—	+	+	+	..	+	+	—	..	Ps. lactis aerogenes A, p. 184
221.23301, - -	—	—	—	+	—	+	±	+	—	—	—	+	—	—	—	—	+	—	+	+	+	+	+	+	..	+	—	+	..	Ps. lactis fluorescens, p. 157
211.23300, - -	—	+	—	+	—	+	+	+	—	—	—	+	—	—	—	—	+	+	+	±	—	±	+	—	..	+	+	—	..	Ps. lactis varians, p. 158
121.2??00, - -	+	+	+	+	+	+	+	+	—	—	—	+	—	—	—	—	..	..	..	+	..	+	+	+	..	+	+	—	..	Ps. ac. presamigenes casei, p. 158
111.22200, - -	—	—	+	+	—	+	+	+	—	—	—	+	—	—	—	—	+	+	+	—	—	+	+	—	..	—	—	+	..	Ps. lactis granula, p. 159

* Gas, not acid.

TABLE 5.

Lophotrichic Rods=Bacillus.

GROUP NUMBER.	MORPHOLOGY.					CULTURAL FEATURES.																BIO-CHEMICAL.						NAME.
						Broth.			Agar.			Gel. Plate.					Gel. Stab.			Potato.			Liquefaction.			Milk.			
	Diameter over 1 μ.	Chains.	Spores.	Motility.	Gram Stain.	Turbidity.	Scum.	Sediment.	Dull.	Wrinkled.	Chromogenesis.	Round-compact.	Proteus-like.	Rhizoid.	Filamentous.	Curled.	Funnel.	Needle growth.	Surface growth.	Abundant.	Discolored.	Grows at 37°.	Gelatine.	Casein.	Blood serum.	Curdled.	Acid.	Alkaline.	Indol.	
112.23301(3), - -	—	—	+	—	±	+	+	+	—	—	+	+	—	—	—	—	—	+	+	+	+	+	—	—	—	—	—	+	..	B. syncyanus, p. 159
212.33304, - - -	—	—	+	—	—	+	+	+	—	—	+	+	—	—	—	—	—	+	+	+	..	+	—	—	—	—	—	+	..	B. lactis olivaceus, p. 160
212.33300, - - -	—	—	+	—	—	+	—	+	—	—	+	+	—	—	—	—	—	+	+	+	..	+	—	—	—	—	—	+	..	B. lactis minutus, p. 160
212.23300, - - -	—	—	—	+	—	+	+	+	—	—	—	+	—	—	—	—	—	+	—	+	..	+	—	—	—	—	—	+	..	B. lactis molecularis, p. 160
121.11108, - - -	—	+	+	+	+	+	—	+	—	—	+	+	—	—	—	—	+	+	—	+	+	+	+	—	..	+	+	—	..	B. lactis Isignii, p. 161
111.23301, - - -	—	—	+	+	—	+	—	+	—	—	—	+	—	—	—	—	+	+	—	—	..	+	+	+	..	+	—	—	..	B. lactis fluorescens I., p. 161
221.23301, - - -	—	+	—	+	—	+	+	+	—	—	+	+	—	—	—	—	+	+	—	±	..	+	+	+	..	+	—	+	..	B. lactis fluorescens II., p. 162
211.00001, - - -	—	—	—	+	..	+	+	+	—	—	+	+	—	—	—	—	—	+	+	+	—	+	+	+	..	+	—	+	..	B. lactis miutissimus, p. 162
221.00001, - - -	—	—	—	+	..	+	+	+	—	—	±	+	—	—	—	—	—	+	+	—	+	+	+	+	..	+	—	+	..	B. lactis fluorescens III., p. 163
211.23300, - - -	+	—	—	+	±	+	+	+	—	—	—	+	—	—	—	—	—	+	—	—	—	±	+	+	..	+	—	+	..	B. lactis moruloideus, p. 163

Table 6.

Peritrichic, Non-Liquefying Rods=Bacillus.

Group Number.	Morphology.					Cultural Features.																Bio-chemical.							Name.
						Broth.			Agar.			Gel. Plate.					Gel. Stab.			Po-tato.			Lique-faction.			Milk.				
	Diameter over 1 μ.	Chains.	Spores.	Motility.	Gram stain.	Turbidity.	Scum.	Sediment.	Dull.	Wrinkled.	Chromogenesis.	Round-compact.	Proteus-like.	Rhizoid.	Filamentous.	Curled.	Funnel.	Surface growth.	Needle growth.	Abundant.	Discolored.	Grows at 37°.	Gelatine.	Casein.	Blood Serum.	Curdled.	Acid.	Alkaline.	Indol.	
212.3330*, - - -	—	—	—	—	—	+	+	+	—	—	+	+	—	—	—	—	—	+	+	+	+	+	—	—	—	—	—	—	..	B. lactis nigroferous, p. 164
212.33300, - - -	+	+	—	+	—	±	—	+	+	—	—	—	—	+	±	—	—	+	+	+	+	+	—	—	—	—	—	+	..	B. lactis Zenkeri, p. 164
212.33305, - - -	—	+	—	+	+	+	—	+	+	—	—	—	—	+	+	—	—	+	+	—	—	+	—	—	—	—	—	—	..	B. lactis Colchesteri, p. 165
212.33301, - - -	—	—	—	+	—	+	+	+	—	—	—	+	—	—	—	—	—	+	+	—	—	+	—	—	—	—	—	—	..	B. lactis nebulus, p. 165
212.22205, - - -	—	—	—	+	..	+	+	+	—	—	+	+	—	—	—	—	—	+	+	+	—	+	—	—	..	..	+	+	..	B. lactis citreus, p. 166
122.22200(7), - - -	—	—	+	+	—	+	+	+	—	—	—	+	—	—	—	—	—	+	+	+	+	+	—	—	—	+	+	—	..	B. lactis rubifaciens, p. 166
222.22200, - - -	—	—	—	+	+	—	—	+	—	—	—	+	—	—	—	—	—	+	+	—	—	+	—	—	—	±	+	—	..	B. lactis sulcatus, p. 166
212.22200, - - -	—	—	—	+	—	+	+	+	—	—	—	+	—	—	—	—	—	+	+	+	—	+	—	—	—	—	+	+	..	B. dysenteriae, p. 167
212.23300, - - -	—	—	—	+	—	+	+	+	—	—	—	+	—	—	—	—	—	+	+	—	—	+	—	—	—	—	—	+	..	B. lactis fragarie, p. 167

TABLE 7—*Peritrichic Liquefying Rods=Bacillus.*

GROUP NUMBER.	MORPHOLOGY.					CULTURAL FEATURES.																BIO-CHEMICAL.						NAME.
						Broth.			Agar.			Gel. Plate.					Gel. Stab.			Po-tato.			Lique-faction.			Milk,			
	Diameter over 1 μ.	Chains.	Spores.	Motility.	Gram stain.	Turbidity.	Scum.	Sediment.	Dull.	Wrinkled.	Chromogenesis.	Round-compact.	Proteus-like.	Rhizoid.	Filamentous.	Curled.	Funnel.	Surface growth.	Needle growth.	Abundant.	Discolored.	Grows at 37°.	Gelatine.	Casein.	Blood serum.	Curdled.	Acid.	Alkaline.	Indol.	
211.33307, - - -	—	—	—	+	..	+	+	+	—	—	+	+	—	—	—	—	+	—	+	+	—	+	+	+	+	+	+	—	+	B. prodigiosus, p. 168
211.11?07, - - -	—	+	—	+	—	+	—	+	—	—	+	+	—	—	—	—	+	—	+	+	—	+	+	+	..	+	+	—	..	B. bulyri rubri, p. 168
221.32305, - - -	—	—	—	+	+	+	—	+	—	—	+	+	—	—	—	—	+	—	+	+	—	..	+	+	..	+	+	—	..	B. lactis citronus, p. 169
211.3??05, - - -	—	—	—	+	+	+	+	+	+	—	+	+	—	—	—	—	+	—	+	+	—	..	+	—	..	—	—	+	..	B. lactis Harrisonii, p. 169
121.23301, - - -	+	+	+	+	+	+	+	+	—	+	+	+	—	—	—	—	+	—	+	+	—	+	+	+	..	+	—	+	..	B. lactis fluorescens IV. p. 170
211.2220*, - - -	—	+	—	+	+	+	+	+	—	+	—	+	—	—	—	—	+	..	+	+	+	+	+	+	..	+	—	+	..	B. lactis niger, p. 170
111.33300, - - -	—	—	+	+	+	+	+	+	—	—	—	—	—	+	+	—	+	—	+	—	—	+	+	—	..	—	—	—	..	B. lactis arborescens II., p. 171
221.33300, - - -	—	—	—	+	—	+	—	—	—	—	—	—	+	+	—	—	+	+	+	—	+	±	+	—	..	—	—	—	..	B. lactis rhizoides, p. 171
111.33300, - - -	+	+	+	+	+	+	+	+	+	+	+	—	—	+	—	—	+	—	+	+	—	+	+	+	..	+	—	+	..	B. lactis mycoides, p. 172
121.33300, - - -	+	+	+	+	+	+	+	+	+	+	—	+	—	—	—	—	+	—	+	+	..	+	+	+	..	+	—	+	..	B. subtilis, p. 172
111.33300, - - -	—	+	+	+	..	+	+	+	—	—	±	+	—	—	—	—	+	—	+	+	+	+	+	+	..	+	—	+	..	B. lactis Cromwellii, p. 173
111.33303, - - -	—	+	+	+	+	+	+	..	—	+	+	+	—	—	—	—	—	+	+	+	+	+	+	—	..	—	±	—	..	B. janthinus, p. 173
211.???00, - - -	—	+	—	+	..	+	+	+	—	—	±	+	—	—	—	—	+	—	+	+	+	+	+	+	..	—	—	+	..	B. lactis circulans, p. 174
121.†††00, - - -	—	—	+	+	—	+	+	+	—	—	—	+	—	—	—	—	+	—	+	+	+	+	+	+	..	—	—	±	..	B. aerolactis, p. 174
211.33300, - - -	+	—	—	+	—	+	±	±	—	—	—	—	+	+	—	—	—	—	+	+	+	+	+	+	..	+	—	±	..	B. lactis tetragenes, p. 175
221.33300, - - -	—	+	—	+	+	+	+	—	—	—	—	+	—	—	—	—	—	—	+	+	+	+	+	+	..	+	—	±	..	B. lactis distortus, p. 175
221.33300, - - -	—	—	—	+	—	+	+	+	—	—	—	+	—	—	—	—	+	—	+	—	—	+	+	+	..	+	+	—	..	B. lactis gelatinosus, p. 176
211.13300, - - -	—	—	—	+	—	+	+	+	—	—	—	+	—	—	—	—	+	—	+	+	+	+	+	+	..	+	—	+	..	B. lactis tenuis, p. 176
221.33300, - - -	—	—	—	+	+	—	—	+	—	—	—	+	—	—	—	—	+	—	+	+	+	+	+	—	..	—	—	—	..	B. lactis tenuis A, p. 177
111.23300, - - -	+	—	+	+	+	+	+	+	—	+	—	+	—	—	—	—	—	—	+	+	+	+	+	+	..	+	—	+	..	B. lactis plicatus, p. 177
121.23301, - - -	+	—	+	+	+	+	—	+	—	+	+	+	—	—	—	—	+	—	+	+	+	+	+	+	..	+	—	+	..	B. lactis amberis, p. 178
111.23200, - - -	—	—	+	+	+	+	—	—	+	+	—	+	—	—	—	—	+	—	+	+	+	+	+	+	..	+	—	—	..	B. mesentericus fuscus, p. 178
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211.23300, - - -	—	—	—	+	—	+	+	+	—	—	—	+	—	—	—	—	—	—	+	+	+	+	+	—	..	+	+	—	..	B. lactis Robertii, p. 181

Table 8.

Bacteria Producing Acid and Gas.

Group Number.	Morphology.					Cultural Features.																	Bio-chemical.						Name.
						Broth.			Agar.			Gel. Plate.					Gel. Stab.			Po-tato.			Lique-faction.			Milk.			
	Diameter over 1 μ.	Chains.	Spores.	Motility.	Gram stain.	Turbidity.	Scum.	Sediment.	Dull.	Wrinkled.	Chromogenesis.	Round-compact.	Proteus-like.	Rhizoid.	Filamentous.	Curled.	Funnel.	Surface growth.	Needle growth.	Abundant.	Discolored.	Grows at 37°.	Gelatine.	Casein.	Blood serum.	Curdled.	Acid.	Alkaline.	Indol.	
212,11100, - - -	+	—	—	—	+	+	+	+	—	—	—	+	—	—	—	—	—	+	+	+	—	+	—	—	—	+	+	—	—	B. lactis aerogenes, p. 184
212,11100, - - -	+	—	—	—	+	+	+	+	—	—	—	+	—	—	—	—	—	+	+	+	—	+	—	—	—	+	+	—	+	B. lactis aerogenes A, p. 184
212,11300, - - -	+	—	—	—	+	+	+	+	—	—	—	+	—	—	—	—	—	+	+	+	—	+	—	—	—	—	+	—	—	B. lactis aerogenes B, p. 184
212,21101, - - -	+	—	—	—	+	+	+	+	—	—	—	+	—	—	—	—	—	+	+	+	+	+	—	—	—	±	+	—	..	B. lactis aerogenes C, p. 185
212,12200, - - -	+	—	—	—	+	+	—	+	—	—	—	+	—	—	—	—	—	+	+	+	+	+	—	—	—	+	+	—	..	B. lactis aerogenes D, p. 185
222,11100, - - -	+	—	—	+	—	+	+	+	—	—	—	+	—	—	—	—	—	+	+	+	—	+	—	—	—	+	+	—	±	B. coli aerogenes, p. 185
222,11100, - - -	+	—	—	+	—	+	+	+	—	—	—	+	—	—	—	—	—	+	+	+	—	+	—	—	—	+	+	—	+	B. coli communis, p. 186
222,11200, - - -	+	—	—	+	—	+	+	+	—	—	—	+	—	—	—	—	—	+	+	+	—	+	—	—	—	+	+	—	+	B. coli communis A, p. 186
222,11100, - - -	±	—	—	+	—	+	+	+	—	—	—	+	—	—	—	—	—	+	+	—	—	+	—	—	—	+	+	—	..	Ps. coli communis, p. 186
222,13300, - - -	—	—	—	+	—	+	+	+	—	—	—	+	—	—	—	—	—	+	+	—	—	+	—	—	—	+	+	—	+	Ps. coli communis C, p. 186

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